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A Summary of Current Program, 10/1/62

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U. S. DEPT. OF AGRICULTURE  
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UNITED STATES DEPARTMENT OF AGRICULTURE

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S. D.A. and cooperative research issued between October 1, 1960, and September 30, 1962. Current Agricultural research findings are also published in the monthly U.S.D.A. publication, "Agricultural Marketing". This progress report was compiled in the Market Quality Research Division, Agricultural Marketing Service, U.S. Department of Agriculture, Washington, D.C. and Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

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TABLE OF CONTENTS

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Page

Introduction.....	ii
Area No. 1 Citrus and subtropical fruit--market quality.....	1
Area No. 2 Dairy products--market quality.....	16
Area No. 3 Deciduous fruits and tree nuts--market quality.....	23
Area No. 4 Grain--market quality.....	52
Area No. 4a Rice--market quality.....	63
Area No. 4b Feed and seed--market quality.....	70
Area No. 5 Livestock and meat--market quality.....	75
Area No. 6 Oilseeds and peanuts--market quality.....	80
Area No. 7 Cotton and cottonseed--market quality.....	88
Area No. 8 Wool and mohair--market quality.....	97
Area No. 9 Potatoes--market quality.....	101
Area No. 10 Poultry--market quality.....	109
Area No. 11 Tobacco--market quality.....	118
Area No. 11b Cut flowers and ornamentals--market quality.....	122
Area No. 12 Vegetables--market quality.....	126
Area No. 13 Insect control in marketing channels--cross commodity....	149
Area No. 14 Instrumentation for objective measurement of market quality.....	159
Line project check list.....	171

## INTRODUCTION

Market Quality research deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of food and fiber, and the development of new methods and devices for the physical and biological evaluation of quality.

The Market Quality Research Division is a part of the Agricultural Marketing Service. It is headquartered in Washington, D. C. The greatest concentration of its scientific personnel is at the Plant Industry Station, Beltsville, Maryland, and includes the 3 Branch headquarters, the Instrumentation Research Laboratory and the Post-Harvest Pioneering Research Laboratory. There are also 14 Field Stations distributed throughout the country including 2 Terminal Market Laboratories. Division personnel are also located at 7 State Experiment Stations. Total research effort including research contracts amounts to approximately 165 professional man-years.

The importance of research on quality protection and measurement and the need for it is demonstrated repeatedly by the heavy losses which occur in the storage, transport, and distribution of food and fiber, as a result of insect attack, microbiological spoilage, physiological deterioration, or some other cause. The dissatisfaction with the quality of commodities as purchased and the tedious methods required in grading and inspection are clear evidence that we need better methods and equipment for quality measurement, grading and classing.

As would be expected, an appreciable part of Market Quality research is closely related to the effective performance of the Service Divisions of the Agricultural Marketing Service responsible for standardization, inspection, and grading of agricultural commodities. In a recent survey, the Service Divisions reported 46 problem areas of work now under investigation by the Market Quality Research Division that have a direct bearing on problems closely associated with standardization, inspection and grading. Of these, 16 were listed as being in the first category of importance. In a concomitant study 74 areas were listed as needing research, and 38 of these were considered in the first category of importance. Examples of previous

research will illustrate this relationship, indicate the varied nature of the research performed, its value to the producer, the consumer and to agriculture in general, and perhaps explain why so many other problems are suggested.

Mechanization of Peanut Grading. A new system and equipment for sampling and grading farmers stock peanuts, whereby the sample is automatically selected in a manner which provides a much more representative sample than was heretofore possible, then shells, counts, and determines the grade more accurately and in a fraction of the time formerly required.

Nondestructive Measurement of Interior Quality of Fruits, Vegetables, and other Commodities. Techniques and equipment have been developed for making measurements of the spectrum of light transmitted through intact fruits and vegetables. These measurements have led to the development of methods to measure the maturity of peaches, apples, plums, and other fruits, to detect black-spot of potatoes, water core or other internal disorders of apples, and blood spots in eggs. Methods can be made available whereby the non-conforming specimens are automatically removed from the packaging lines.

Protective Treatments Against Insect-Infestations. The development of insecticide coatings, the improvement of package construction and the use of laminated heat-sealed tape over stitching have effectively prevented insect invasion and penetration of flour bags for 2 years. Mothproof treatments with DDT applied to rolls of cloth during the sponging process have effectively protected the cloth exposed to heavy insect infestation for 13 years. Insecticide treatments and sanitation practices were developed for dry milk processing plants that effectively put an end to the great losses suffered from insect contamination and the threat of closing down of a number of plants. Economical and effective treatments for grain during storage and shipment have been developed and are now in use in commercial storages, in ships storing surplus grain and in facilities used for transporting grain. Methods for protecting farmers stock peanuts have also been worked out. These developments alone have been worth many millions of dollars per year.

Direct Detection of Phytochrome. By use of spectrophotometric techniques developed by marketing research workers, the important plant pigment, phytochrome, which controls photoperiodic response of plants, has been detected by direct measurement instead of indirect action spectra method used previously. Direct measurement makes possible the isolation and characterization of the pigment and a study of its properties.



Forecasting Storage Quality of Table Grapes. Decay is the limiting factor in grape storage. A procedure was developed and is now in commercial use whereby the storage quality of individual lots can be forecast shortly after harvest. Those with short storage potentials can then be marketed first while still salable, thus preventing unnecessary losses, and making for a more orderly marketing of the product. The principle should be applicable to other commodities as soon as the specific details for the different products are worked out. It has already been applied with considerable success to apples in the Northwest.

Sprout Inhibitors and Storage Temperature for Potatoes. Potatoes stored at 40° or lower, a temperature required to prevent sprouting, are often not suitable for potato chips or French fries. The development of methods for using certain chemicals as sprout inhibitors together with the discovery that most potatoes will retain good processing qualities if stored at 50° to 55° F. has provided good quality potatoes for processing over a long period each year. This work has helped to extend the market for potatoes used for processing.

These examples of research accomplishments illustrate the variety of work engaged in and its potential value in prevention of damage to the commodity and loss of quality. The savings made by this kind of research, benefiting both the consumer and the producer, amounts to many millions of dollars each year. The year-round supply of a great variety of wholesome, nutritious food, some of it extremely perishable, is tangible evidence of the progress in the handling, transportation and storage of food. The research of the U. S. Department of Agriculture in this field over the past 50 years has made a major contribution to the practices now in use in the marketing of agricultural commodities.

## AREA NO. 1 CITRUS AND SUBTROPICAL FRUIT -- MARKET QUALITY

Problem. Research is needed on the measurement of quality in citrus and other subtropical fruits. With a better understanding of quality characteristics and objective indices for the measurement of quality, grades and standards would be more meaningful and could be better enforced. In addition instrumentation for quality measurement lends itself to ultimate automatic devices for quality sorting on a commercial basis. Fruit soilage and wastage resulting from post-harvest decays of citrus fruits present serious problems in both domestic and export markets. Much research is needed to relate handling practices, packaging, precooling and transit refrigeration to decay and soilage, and to develop and evaluate physical and chemical treatments for decay reduction. Research is also needed on the storage of citrus fruits. Optimum storage temperatures for the principal varieties of oranges produced in different areas need further investigation. There is also a vast field for research on controlled atmosphere storage for oranges, grapefruit and lemons. Problems exist in each of the geographical areas which are sometimes distinct and sometimes interrelated, but which require biological research in the separate production areas for solution. Several species of common stored-product insects attack dried citrus pulp animal feed and may build up tremendous populations. In some cases wholesalers and retailers have refused to handle the product because the excessive insect infestation creates a hazard to other commodities in stock. There is an urgent need for effective preventive measures to be used in warehouses that will not leave hazardous residues in the feed, and for the development of packaging that will resist insect infestation of the product in marketing channels.

### USDA PROGRAM

The Department has a continuing program involving largely applied research performed by horticulturists, plant physiologists, plant pathologists, and food technologists. The work is conducted in the producing areas of California, Florida and Texas. Market studies are made in New York City and Chicago. A P.L. 480 grant for research on chemical and physiological variables in avocado and papaya fruits during ripening and storage has been made in Columbia, South America. Studies on objective measurement of quality are conducted under contract by the California Agricultural Experiment Station. The work on avocados, mangos, and limes is done in cooperation with the Florida Agricultural Experiment Station. The work on storage and

export shipments of grapefruit is conducted in cooperation with the Florida Agricultural Experiment Station, the Florida Citrus Commission, and the Foreign Agricultural Service. The work on papayas is in cooperation with the Hawaii Agricultural Experiment Station. The biphenyl work is conducted in cooperation with the California Citrus Research Committee. Irradiation research is done in cooperation with the Quartermaster's Food and Container Institute.

Total federal professional man years devoted to this area is 13.3. Of this 1.6 is devoted to objective measurement of quality; 3.1 to quality maintenance in storage; 3.1 to quality maintenance during transportation; 0.7 to post-harvest physiology; 4.3 to post-harvest disease control; and 0.5 to program leadership. A PL-480 project recently initiated in Columbia involves \$64,115 equivalent in pesos over a 3-year period.

Work terminated during the period included studies on rind breakdown in citrus fruit (MQ 2-1), fungicidal methods for control of Florida citrus (BS 2-50), export tests of California citrus (BS 2-171), truck shipments of western citrus (BS 2-140), seasonal changes in Marcott Honey oranges (BS 3-67), maturity measurement in avocados (BS 3-144), automatic sorting of dates for moisture content (BS 3-66), and storage of Pope's summer oranges (Part of MQ 2-51)

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

In 1961, the State Experiment Stations reported 13.9 professional man years divided among subheadings as follows: Objective measurement and evaluation of quality 4.6, handling and packaging 1.2, storage 1.7, transportation 0.1, post-harvest physiology 2.4, and disease control 3.9. Measurement and evaluation of quality includes size, shape and appearance of avocados with respect to quality; physical, chemical, and organoleptic properties of citrus oils on flavor stability; enzymatic activity; gelation of citrus juices; relation of environment, cultural properties, and maturity on quality; isolation and identification of volatile compounds affecting quality; and influence of plant regulators on quality of fruit. Handling and packaging includes time-temperature studies, coating materials, pre-cooling, and physiological and biochemical changes. Storage work includes physical and chemical changes; effects of mineral nutrition on metabolic changes in storage; and microorganisms of stored juices. Transportation work includes cause and control of brown rot in lemons, and composition studies of avocados. Post-harvest physiology includes the biochemistry of maturation of avocados, and the physiological, chemical, and enzymatic changes in citrus. Disease control includes effects of rapid cooling as related to control measures and a study of fundamental differences between susceptible and resistant fruits.



Industry and other organizations. Research by chemical companies on products to control decay of citrus fruit amount to an estimated annual expenditure equivalent to approximately 2 professional man years. Similarly a large cooperative in California does research on disease control, packaging and transportation amounting to about 2 man years, and the Florida Citrus Commission about 1 man year on packaging and decay control.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement of quality

1. Study of Seasonal Changes in Quality of Murcott Honey Oranges for Use in Developing Maturity Standards. (Florida) Palatability in the Murcott Honey orange changed from unacceptable in December to prime eating quality in February and March, and dropped slightly in April. Total solids increased in a similar fashion. Total solids-to-acid ratio, pH, fruit weight, and volume of juice increased with maturity and ripening on the tree, while ascorbic acid and total acid dropped throughout the season. Fruit grown on sour orange, Cleopatra, and sweet orange rootstocks were of better quality than those on rough lemon. A report on this work will soon be published. (BS 3-67)

2. Relation of Physical Properties, Chemical Composition and Metabolic Activity to Market Quality of Citrus. Studies were conducted in Florida to determine if Valencia oranges could be sorted by light transmittance techniques according to their need for degreening so that oranges would be held with ethylene at high temperatures for only the minimum length of time necessary for degreening. Treatment based on need for degreening should reduce decay and rind disorders.

Two tons of early Valencia fruit were separated into four groups according to the amount of green pigment in the rind. Twenty-five percent of the fruit were well colored and required no ethylene treatment. Twenty percent required between 16 and 40 hours degreening with ethylene. About 24 percent were satisfactorily degreened in 48 hours while those fruit classed as the greenest (31 percent) did not degreen satisfactorily in 64 hours.

Quality separation was also achieved in these tests. Green fruit sorted by the light transmittance instrument had an average Brix/acid ratio of 9.8 while the progressively less green fruit had average ratios of 11.7, 12.6, and 14.4, respectively. Non-separated fruit averaged 12.5.

The research contract with the California Citrus Experiment Station on changes in metabolism of oranges during maturation has progressed satisfactorily. Two incubation series for labeled sucrose, glucose, acetate, carbon dioxide, and phosphate have been completed. No significant findings which can be related to maturity evaluation in oranges are evident as yet.

Tests were made in Florida with an instrument for measuring firmness of individual fruits. With adequate procedures repeated tests can be made without damaging the fruit. Preliminary studies were made on changes in firmness as a result of various treatments. Grapefruit softened in storage and also with maturity. Ethylene treatment accelerated softening. (MQ 3-20)

3. Development of Maturity Measurements in Avocados. From June 1960 to January 1961, over 1,000 avocados, representing 9 varieties, were studied in Florida. Except for the Taylor variety, oil content in the fruit was similar to that found during previous seasons. Oil content increased as the season progressed; however, variation in oil content among individual fruits was so great that it precluded the use of this method in determining maturity. (BS 3-44)

4. Development of Method and Equipment for Automatic Sorting of Dates for Moisture Content. This work was conducted under contract in California. The contractor has completed and tested the demonstration model of a date sorting machine. This machine provides four moisture classifications: (1) 17 percent or less, (2) 17 to 21.5 percent, (3) 21 to 25.5 percent and (4) over 25 percent. It is capable of sorting dates at a speed of four dates per second. The machine has been tested in a date-processing plant and has been shown to meet the requirements of the date processors. (BS 3-66)

#### B. Quality maintenance in storage

1. Controlled Atmosphere Storage of Citrus Fruit. Experiments were continued to extend the storage period of Texas red grapefruit by controlling the storage atmosphere. Pretreatment for 4 days at 80°F following harvest was effective in reducing decay and pitting in fruit stored early in January but not in fruit stored in late November. This treatment also reduced decay of fruit held in air.

Decay was of no importance in any of the lots during the first 98 days storage. At the end of 140 days, January-harvested fruit stored at 41°F was 32 percent decayed and November-harvested fruit, 74 percent. However, when stored at 46°, losses of January fruit were only 5 percent and of November fruit, 9 percent.

Washington navel oranges were stored in California up to 4 months in 5 percent oxygen and no carbon dioxide, and in 5 percent oxygen and 5 percent carbon dioxide at 40°F. Flavor and appearance were retained well in the atmosphere containing 5 percent oxygen and no carbon dioxide, but the flavor was impaired in oranges held in the atmosphere containing 5 percent carbon dioxide. Oranges stored in normal air retained flavor quite well, but deteriorated in appearance because of shrinkage and dullness. Decay was much more prevalent in oranges stored in controlled atmospheres than in comparable fruit stored in air. (MQ 2-48)

2. Storage of Pope's Summer Oranges. (Florida) Pope's summer oranges stored 2 and 3 months at 32°F developed much less decay and rind breakdown during the subsequent 7-day holding period at 70° than fruit stored at 38°F. In 1960, oranges picked in April had less decay after storage than fruit picked in May. The use of 1 percent Dowicide-A and  $\frac{1}{2}$  percent hexamine with a wax reduced the occurrence of decay during the holding period after removal from 38°F storage. Fruit picked in April 1960 and May 1961, with solids-to-acid ratios of 18.5-to-1 and 17.5-to-1, respectively, maintained their internal quality during the storage and holding period. Storage off-flavors developed in fruit picked in May 1960 with a solids-to-acid ratio of 23.4-to-1 at harvest. (MQ 2-51)

3. Ripening and Storage of Florida Mangos and Avocados. The most satisfactory temperature for mango storage still appears to be 60°F. Skin color becomes bright at this temperature. Fruit slowly softens (2 to 4 weeks) at this temperature and the flavor of the softened fruit is tart. Ripening at 70° to 80° for 1 or 2 additional days then is necessary for the fruit to become sweet and of good quality. Fruit displaying a color break will withstand storage temperatures below 50°F without becoming injured while those with no color break become injured.

A temperature of 55°F still appears to be both a safe storage and ripening temperature for most avocado varieties. Some varieties developed chilling injury at 50°F. (MQ 2-46)



4. Factors Influencing the Storage and Shelf Life of Florida Persian Limes. Limes dipped in polyethylene emulsions were greener and fresher in appearance than controls after 10 days at 70°F. Limes held at 50°F for 1 month in unventilated polyethylene bags retained a fresh green appearance better than those not bagged but had more decay. (MQ 2-40)

C. Quality maintenance during transportation

1. Prestorage Treatments and Simulated Transit Temperatures for Florida Grapefruit. Studies were conducted to determine the best transit temperature for Florida grapefruit exported at different seasons of the year. Sixty degrees was found to be the best temperature for Marsh Seedless and Ruby Red grapefruit harvested in October and December. Excessive pitting and decay developed on October harvested grapefruit during the 3-week simulated transit period at 40° and 50°F and the subsequent 2-week 70° holding period. October- and December-harvested fruit held at 32° developed considerable brown staining during the 2-week 70°F simulated marketing period which detracted from the market appearance.

In the fruit harvested in March, little differences were noted in the keeping quality of the grapefruit held at 50° and 60°F. Excessive decay and pitting developed on fruit held at 32° and 40°F. Excessive decay developed in May-harvested fruit at all temperatures; however, grapefruit held at 50° and 60°F had the least amount of pitting and decay.

Washed (but not waxed) grapefruit harvested in October and December developed good color during the 2- to 3-week simulated transit period at 60°F. No pitting and little decay developed under these conditions. When this early grapefruit was waxed, a minimum of 36 to 38 hours of degreening was required for good color to develop. (MQ 2-51)

2. Export Shipment of Florida Grapefruit. In an April test shipment of grapefruit to Hamburg, temperature and humidity aboard ship were accurately maintained in refrigerated stowage but fluctuated in ventilated stowage. No commercially significant rind breakdown developed during the voyage or during the 2-week holding period at 60°F.

Marsh Seedless grapefruit stowed in a refrigerated hold at 50°F arrived with about 1 percent decay, while those stowed at 60° arrived with about 4 percent decay. After storage at 60° for 7 days, the 50°-stowed fruit had about 3 percent decay, and the 60°-stowed fruit had about 8 percent decay; after 14 days the former had about 5 percent, the latter about 13 percent.



Marsh Seedless grapefruit stowed in the ventilated hold (average temperature between 50° and 60°) arrived with about 3 percent decay and developed about 6 percent decay after 7 days at 60°F, and about 11 percent decay after 14 days at 60°. Although the Ruby Red grapefruit followed the same decay pattern as the Marsh Seedless, decay was considerably less, probably due to source differences. Green mold was the frequent disorder on arrival, which indicated fruit injury had taken place. Stem end decay predominated during the 2-week holding period at 60°. (MQ 2-51)

3. Truck-Rail Tests (Cooperation with T & F) Four truck-rail piggy-back tests from Florida under ventilation service showed a need for improved loading pattern, modification of the front bunker to provide forced air through longitudinal channels in the load, and the development of a method by which air can be directed into the trailer when the rear of the trailer faces forward, as is often the case after loading on a rail car.

Five truck-rail test shipments with mechanically refrigerated units provided good peripheral cooling but heat from the center of the load was removed slowly. (MQ 2-53)

4. Maintaining the Quality of Hawaiian-Grown Papayas During Shipment to Continental United States. Three test shipments by ship and three by plane were conducted during the year. Papayas shipped by air remained salable about 2 days longer than those transported by ship. Precooling extended the salable life 1 day. Hot water treatment reduced decay by about one half compared with the ethylene dibromide treatment. (MQ 2-25)

#### D. Post-harvest physiology

1. Cause and Prevention of Rind Breakdown in Citrus Fruits. Tests in Florida indicated that desiccation alone by exposure to high temperature, low humidity, and high air flow did not produce rind breakdown in oranges. However, rind breakdown of oranges was produced by a delay between harvest and washing. The amount of rind breakdown increased with the length of delay and with the amount of time fruits stayed on the brushes in the packing line. Pineapple and Murcott Honey oranges were more susceptible than Valencia oranges. High temperature and low humidity during delays after harvest increased susceptibility of Valencia oranges. Post-harvest application of fungicides increased the incidence of rind breakdown only slightly and caused no rind breakdown when the fruit was treated on the day harvested. A report on this work is being prepared for publication.

Experiments were continued in Texas to find the cause and control of rind-oil spotting (Oleocellosis) in Marrs Early Orange. A correlation was found between the evaporation rate at 2:00 p.m. from a black porcelain atmometer placed in the orchard and the spotting susceptibility of fruit picked at the same time. High evaporation rates were associated with low susceptibility to spotting. However, rind-oil spotting was not very prevalent during the 1961 season, and there were not sufficient samples representing great susceptibility and/or low evaporation rates to consider this correlation conclusive. Growers and shippers who have followed recommendations to pick Marrs Oranges only in the afternoons of clear, sunny days, and defer picking after rain or irrigation for 2 or 3 days have had less oleocellosis on this variety than formerly. (MQ 2-1)

2. Effects of a High Nitrogen-Low Oxygen Atmosphere on Bananas. Because of the interest in the use of liquid nitrogen for transit refrigeration and the possibility of having a nearly complete nitrogen atmosphere with little or no oxygen in the transit vehicle, studies were initiated at Beltsville to determine the effects of low oxygen on the fruit. Ripening of green bananas held at 60°F in both 99 and 100 percent nitrogen was retarded. After holding in 100 percent nitrogen for 4 days, bananas ripened slowly in normal air to a dull, yellow color but with normal flavor. After 7 or 10 days in 100 percent nitrogen, bananas ripened poorly or not at all, and were off-flavored. Bananas held in 99 percent nitrogen and 1 percent oxygen for periods up to 10 days ripened in a normal manner with no off-flavor after being removed to normal air. (MQ 2-71)

#### E. Post-harvest disease control

1. Factors Influencing the Accumulation of Biphenyl in Citrus Fruits and its Effectiveness for Decay Control. California lemons harvested at the B-silver or tree ripe stage decayed more in storage, either with or without biphenyl, than lemons harvested when dark or light green and cured 3 weeks prior to experimental storage.

Biphenyl residue in lemons packed with biphenyl treated sheets rarely exceeded 30 p.p.m. after a simulated overseas transit period (4 weeks) plus a distribution period (2 weeks). All fruit had residues well below the German legal tolerance of 70 p.p.m. Biphenyl residue was 50 to 100 percent higher in lemons held in nonvented cartons than in lemons held in vented cartons under similar conditions. Lemons exposed to biphenyl free air for 1 week at 68°F lost about one-half of the biphenyl absorbed during storage in treated cartons. A report on the results with lemons has been prepared.

The sporulation on California-grown navel oranges inoculated with Penicillium digitatum (Green mold organism) was at least twice as much on fruit in vented cartons with biphenyl sheets as on fruit held under comparable conditions in nonvented cartons. Sporulation was greater on Valencia than on Washington navel oranges held under similar environments, but the nonvented carton was also better than the vented carton for Valencias when biphenyl was used. Sporulation on inoculated navel and Valencia oranges held without biphenyl was appreciably more than on similar fruit held with biphenyl.

Oranges absorbed about twice as much biphenyl as lemons held under the same conditions. Oranges lost biphenyl only one-third as fast as lemons when held in open trays in biphenyl free air after storage.

A method for measuring biphenyl vapor in carton atmospheres was developed. The concentration in vented orange cartons after 1 week at 68°F was 2 to 3 micrograms per liter of air and in nonvented cartons 13 to 33 micrograms. Air saturated with biphenyl at this temperature contains about 50 micrograms biphenyl per liter. The sporulation index was inversely related to the biphenyl concentration. (MQ 2-28)

## 2. The Incidence and Nature of Biphenyl-Resistance in Lines of Penicillium Digitatum and its Effects on Decay in Citrus Fruits.

About 350 clones of the green mold fungus have been screened for resistance to biphenyl in California. As a result several pertinent facts were established:

- (a) Fungus strains differ markedly in sensitivity to biphenyl vapors, some being extremely sensitive, others inherently tolerant.
- (b) Resistant strains of the fungus are not limited geographically.
- (c) It is possible to separate resistant fungus strains by simple in vitro tests.
- (d) Resistance in strains of the fungus is not necessarily caused by continuous exposure to the fungistat but can be demonstrated in strains never previously exposed to biphenyl.
- (e) The efficacy of biphenyl in protecting packaged citrus fruit against decay and soilage caused by the green mold fungus is not absolute and depends largely on proper holding temperatures. (MQ 2-26)



3. Fungicidal Control of Decay of California Citrus Fruits. 2, 6-dichloro-4-nitroaniline was compared with sodium-orthophenylphenate for control of blue and green molds of citrus. Green mold development was retarded but not eliminated in inoculated lemons dipped in solutions of either material. Mold development was also reduced in lemons dipped in water at 131°F adjusted to pH above 11.5 with potassium hydroxide. (MQ 2-24)

4. Control of Postharvest Diseases of Florida Citrus Fruit. Eleven new fungicides were screened for the control of stem-end rot and green mold of oranges. Two compounds (Dibromotetrachloroethane and Secondary-butylamine) were found sufficiently effective to warrant further testing during the coming season.

Grove inoculations were made at monthly intervals on Partin Delicious oranges and Dancy Tangerines with spore suspensions of the two stem-end rot fungi during the summer and fall of 1961. The incidence of stem-end decay after harvest was considerably increased for both the Phomopsis and Diplodia inoculated fruit over the uninoculated fruit. This shows that these fruit are susceptible to infection by both stem-end rot fungi throughout their growing season.

One hundred twenty-one isolations of green mold (Penicillium digitatum) were made from grove infected citrus fruit collected throughout the citrus area. These were tested for reaction to biphenyl and sodium-orthophenylphenate. Of these cultures, 23 were slightly to moderately resistant to biphenyl and 4 were slightly resistant to sodium-orthophenylphenate. None were immune or even highly resistant to either of these standard fungicides. Hot water (122-131°F) for the control of Phomopsis and Diplodia stem-end rots and green mold showed promising results. Up to 75 percent decay reduction resulted in Pineapple oranges artificially inoculated with green mold or stem-end rot fungi. Less striking results were obtained with naturally-infected fruit. The undesirable feature of this method of control appeared to be the narrow range of time and temperature at which control is affected and physiological rind breakdown (aging and pitting) increased.

Decay, particularly stem-end rot and side rots (Colletotrichum and Phomopsis) increased when fruit was brushed excessively and when there was a delay in washing and otherwise handling fruit following harvest. In general, the longer the delay up to 4 or 5 days, the greater was the amount of total decay and rind breakdown. (MQ 2-65)



In three holding tests conducted during the normal Murcott Honey orange harvest season very little decay or rind breakdown developed during 3 weeks at 70°F. Standard fungicides reduced the decay slightly. This variety apparently has a potentially good shelf life in comparison with other specialty fruits (e.g., tangerines or Temple oranges) which show considerable wastage after 10 days to 2 weeks. (BS 2-50)

5. Irradiation for Control of Post-Harvest Diseases. (Chicago, Ill) Irradiation of lemons increased the susceptibility of the fruit to sour rot, (Geotrichum candidum). Severe injury to the fruit at or near 200 kilo rad precludes the use of radiation for the control of this disease.

Low levels of gamma radiation delayed ripening of Persian limes but increased stem-end decay (Alternaria citri). Doses of from 25 to 75 kilo rad weakened fruit so that after 3 weeks at 50°F there was an increase in alternaria decay proportional to the gamma dose. Green mold decay (Penicillium digitatum) was neither increased nor retarded by these low levels of radiation. All dosages used retarded yellowing.

Irradiation of Irwin and Sensation mangos with gamma rays retarded ripening. Only the lowest doses, 10,000 rads for Irwin, and 15,000 rads for Sensation, did not impair flavor.

Treatments of 17,000 rads/min. and 37,000 rads/min. for a total dose of 182,000 rads gave complete control of green mold of navel oranges for 7 days. The same total dose given at the rate of 2,000 rads/min. and 12,000 rads/min. was only partially effective. (MQ 2-32)

6. Control of Anthracnose on Mangoes. From preliminary results in Florida, a hot water treatment not exceeding 5 minutes in the range of 130° - 140°F is promising for the reduction in severity of anthracnose in the Hayden variety. Above these temperatures, the fruit scalded. Fruit treated in the mature-green stage is less susceptible to scalding than fruit treated after it has begun turning yellow. (MQ 2-68)

7. New Storage and Market Diseases. Gray mold rot of avocado fruit, apparently previously unreported, has been found on the New York market. The causal organism was isolated and identified as *Botrytis* sp., probably *B. cinerea*. The isolate was found to be pathogenic to hard and firm avocados, forming, firm, chocolate-brown lesions that eventually penetrated to the seed cavity.

A pitting disease of bananas caused by Piricularia grisea was isolated from bananas from Chicago and Milwaukee markets. The disease is characterized by small, brown to black, circular, sunken pits which are confined to the skin. Growth of the organism in vitro was slow at 55°F and most rapid at 89°F. (MQ 2-64)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

Long, W. G., Sunday, M. B., and Harding, P. L. 1962. Seasonal changes in Florida Murcott Honey Oranges. U.S.D.A. Tech. Bul. No. 1271. (BS 3-67)

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Quality Maintenance in Storage

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## AREA NO. 2 DAIRY PRODUCTS -- MARKET QUALITY

Problem. Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage life of dairy products. Several kinds of stored-product insects and mites damage or contaminate dairy products and cause extensive losses, principally in nonfat dry milk and cheese. The losses are important not only to the dairy industry but also to the Department in connection with its price support and storage program. To maintain quality of these products in marketing channels, research is urgently needed on the factors influencing keeping quality, and on the development of safe and effective procedures for controlling and/or preventing infestation in warehouse storage, and during transportation by rail, as well as by packaging to provide better protection for nonfat dry milk against infestation. New and improved objective quality tests are also needed for bulk milk and other products. A related problem is the occasional presence of antibiotic and pesticide residues for which improved detection methods are needed.

### USDA PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. Work is being done at Beltsville, Maryland, and a 2-year contract with the University of California, Davis, California, on protein estimation by dye-binding methods. The Federal scientific effort devoted to research in this area totals approximately 1.0 professional man-years.

A contract with the University of Helsinki, Finland, provides for study of the types of bacteria responsible for the deterioration of market milk. Its duration is 2 years, 1960-1962, and involves P. L. 480 funds with a \$32,462 equivalent in Finmarks.

Also, there is a long-term program involving entomologists and chemists engaged in basic and applied research on the prevention of insect infestation and contamination of dairy products in the marketing channels. Cooperative work with the Wisconsin Agricultural Experiment Station, the Commodity Credit Corporation, and industry groups are included. In addition to work specifically aimed

at insects attacking dairy products, done at Madison, Wisconsin, studies applicable to other insects as well, are conducted at Savannah, Georgia, and are reported in Area 13 "Insect Control in Marketing Channels."

The Federal scientific effort in the insect studies totals 2.5 professional man-years divided as follows: Basic biology and ecology 0.5; insecticide evaluation 0.9; insecticide residues 0.4; insect resistant packages 0.4; and program leadership 0.3.

A research project concerned with developing tests for the sanitary condition of nonfat dry milk was completed.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 10.3 professional man-years divided among subheadings as follows: Objective measurement and evaluation of quality, 5.9; quality maintenance in handling and packaging, 3.0; quality maintenance in storage and transportation, 1.3; insect control, 0.1. Work on objective measurement and evaluation of quality includes sensitivity and accuracy of methods for detecting inhibitory substances in market milk; foreign flavors in dairy products and their identification; composition, physical, chemical and microbiological changes in cottage cheese; physical and chemical investigations on chocolate milk; organoleptic evaluation of ice cream mixes of varying composition; procedures for quality control; and lipase action in market milk. Handling and packaging include research concerning the influence of distribution methods on flavor, composition, and bacteriological conditions of cottage cheese; microbiological and enzymatic changes in fluid milk; microbiological studies on bulk handling of milk; determination of normal freezing point and the incidence of antibiotics in market milk; influence of fluorescent light on milk stored in various containers; and the influence of ice cream packaging materials on quality of ice cream. Storage and transportation research include chemical and bacteriological changes that take place during the bulk storage of milk, lipase activity, and characterization of microorganisms responsible for spoilage. Insect control research is on means to control mites and other insects that infest cheese and dry milk solids that are held in storage for extended periods.



Industry and other organizations conduct research on pesticide and antibiotic residues, microbiological problems related to market quality, and instrumentation. Estimated annual expenditures are equivalent to approximately 20 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement and evaluation of quality

1. Pesticide Residues. Work was continued on improved methods of detection of chlorinated insecticide in dairy products with emphasis on development of one-step chromatographic cleanup procedures which can be used prior to detection and semiquantitative estimation of the insecticides by paper chromatography. An effective and broadly applicable procedure for this purpose was developed using florisil. This provides a relatively simple and sensitive screening procedure for detecting chlorinated insecticide residues in dairy products. A second chromatographic technique using decolorizing carbon was also developed. This was slightly less effective than florisil with most insecticides but it works in some cases where no other chromatographic procedure is known. These chromatographic techniques should be of general value to analysts in the pesticide residue field because no satisfactory chromatographic cleanup techniques were previously available for many of the insecticides studied.

(MQ 3-11)

2. Protein Content. The work on protein estimation by dye-binding methods is being carried out under contract with the University of California. The amido black procedure was selected for use in this study. Optimum conditions for this procedure have been selected and data have been obtained from 574 milk samples. Preliminary examination of results indicates good agreement between dry-binding and Kjeldahl procedures for protein. Statistical analyses have not been completed.

(MQ 3-14)

3. Microbiological Studies. The final report on the study of the direct microscopic count (DMC) carried out under contract with Iowa State University was received. The results showed the effects of heating on direct microscopic count using two methylene blue stains at various stages in the manufacture of nonfat dry milk (using two methylene blue stains). Decreases in count from raw to the dry milk occurred, particularly with rod forms of bacteria. Fair



correlation between DMC's of raw and dry milk was obtained. Staining methods were studied, compared, and some recommendations for improving the techniques were made.

(BS 3-61)

The P. L. 480 contract with the University of Helsinki has been concerned with the activities of microorganisms causing spoilage of market milk. Pseudomonads were implicated as the type of organism chiefly responsible for spoilage at refrigerated temperatures. Pure cultures of pseudomonads did not produce the spoilage observed in actual market milk. Commercial samples of poor keeping quality always contained two or more strains of pseudomonads showing that milk spoilage may result from synergistic action of several kinds of bacteria. Progress has been made on development of a "key" method for identification of bacteria isolated from market milk. It was found that so-called "restoration" of heat-treated bacteria was more apparent than real. Supposedly homogeneous cultures of bacteria really consisted of two distinct populations, one of which was more heat resistant and also more fastidious in its nutritional requirements. After heating, the more heat resistant cells will multiply on suitable media and partially revert to the other type, thus giving the appearance of "restoration" of heat injured bacteria.

(E8-AMS-2(a))

## B. Prevention of insect infestation

1. Basic Biology and Ecology. Preliminary studies were conducted to explore the sex attractancy of three species of dermestid beetles that are serious pests in dry-milk processing plants, as well as when the product is in transit or storage. Using a technique developed at the Madison, Wisconsin, laboratory specifically for this study, the existence of a natural chemical sex attractant in Trogoderma glabrum, T. inclusum, and the black carpet beetle was demonstrated. Further studies are continuing with the objective in mind of potential utilization of the attractant for detecting and/or controlling these insects.

(MQ 1-4)

2. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area although much of the work is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore, the entire report is included in Area 13.

Studies at Madison, Wisconsin, revealed that malathion, which is currently recommended as a residual spray for dermestid beetle control in dry-milk processing plants and storage areas, is almost instantly detoxified by concrete, a common surface in such locations, and by latex paint commonly used on wall surfaces in the processing plants. It was found that an application of certain traffic marking paints or silicone water proofing treatments prior to the insecticide treatment prevented this detoxification. The search continued for more effective residual sprays. Bayer 29493 was found to be more toxic than malathion on masonite against Trogoderma glabrum but less effective against T. inclusum. It was effective for a time after application to concrete but did not retain toxicity upon aging.

(MQ 1-4)

An article by F. O. Marzke entitled, "Food preference and forced feeding studies with T. inclusum and the black carpet beetle as pests of the dry milk industry," has been submitted to the Journal of Economic Entomology and publication is anticipated in February 1963.

(MQ 1-4)

Synergized pyrethrum continues to be the most effective residual treatment against cheese mites. It appears also to involve a minimum hazard of residues, off-odors, or off-flavors in cheese. Naled, Dimite, dinitrocyclohexylphenol, and chlorobenzilate were promising in preliminary laboratory evaluations but did not hold up for any extended period under more practical testing. DDVP caused no off-flavor in cheese exposed to repeated applications, but later tests indicated it may not be as toxic to mites as suggested by results of preliminary tests.

(BS 1-67)

A special test cage was devised for exposing mites to fumigants. The mites are tiny, fragile, and difficult to manage under experimental conditions. The new type of cage permits observation of the mites and prevents contamination by stray mites during the post-exposure holding period. All mites exposed for 24 hours to methyl bromide at the rate of 1 pound per 1,000 cubic feet were knocked down or dead when the temperature was 35° F. At temperatures of 45°, 55°, and 65° the mites were all dead.

(MQ 1-6)

3. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

4. Insect-resistant Packaging. As with insecticide evaluation and residue analysis, the cross-commodity packaging work at Savannah, Georgia, is reported in Area 13.

Several kinds of multiwall paper bags with 3-mil polyethylene inner liners were tested at Madison to evaluate their resistance to invasion and penetration by insects that commonly infest nonfat dry milk packages. Bags with stitching through the tape closure were most easily invaded. Smooth flat bags with a polyethylene-laminated, heat-sealed tape over stitching were not invaded during a 12-month exposure to insects. Residues were detected in dry milk stored 6 months in bags with the outer ply treated with synergized pyrethrum or methoxychlor. Such residues of synergized pyrethrum are covered by a temporary Food and Drug tolerance but there is none for methoxychlor.

(MQ 1-13)



PUBLICATIONS REPORTING RESULTS OF USDA AND  
COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

- Moats, William A. 1961. Chemical changes in bacteria heated in milk and other media as related to loss of stainability, Journal of Dairy Science, XLIV(8): 1431-1439.
- Moats, William A. 1962. One-step chromatographic cleanup of chlorinated hydrocarbon pesticide residues in butterfat. I. Chromatography on silic acid, Journal of the Assoc. Off. Agr. Chem., 45: 355-358.
- Moats, William A. 1962. Cleanup of some chlorinated insecticides in butterfat by chromatography on florisil, Abstract, American Chemical Society.

Prevention of Insect Infestation

- Stored-Product Insects Branch and Wisconsin Agricultural Experiment Station. 1962. Insect prevention and control in plants processing dry milk, USDA AMS-302 Revised, May 1962, 12 pages.

### AREA NO. 3 DECIDUOUS FRUIT AND TREE NUTS -- MARKET QUALITY

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Additional information is needed with respect to the accurate measurement of market quality and the effects that various handling practices and procedures have on the maintenance of quality. Objective measurements of quality would greatly assist in standardization and grading procedures and the development of instrumentation for this purpose greatly increases the chance for ultimate automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Consistently safe and effective transportation of the more perishable fruits can be accomplished only by continued research with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits are subject to insect infestation from the time they are being dried in the field until they reach the final consumer. There is need for research to develop more effective measures to prevent this infestation all along the line, as raisins are drying in the field, during storage while they await processing, in the processing plant, and after they are packaged. Research is also needed to develop effective measures for protecting tree nuts against insect infestation during storage and after packaging.

#### USDA PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, food technologists, chemists and entomologists. The research in horticulture includes both measurement of quality and maintenance of quality during the period between harvest and consumption. Locations include the headquarters laboratory at Beltsville, Maryland; field laboratories at Wenatchee, Washington; Fresno, California; and Raleigh, North Carolina; and market laboratories in Chicago, Illinois and New York City, and contract work at Corvallis, Oregon with the Oregon State Experiment Station. Also there is a continuing long-term program at Fresno, California, which involves entomologists in applied research on the prevention of insect infestation, damage, and contamination of dried fruit and tree nuts in marketing channels. The research is conducted in cooperation with California State and County agencies and with several industry groups. Basic and developmental studies at

Savannah, Georgia, involve entomologists and chemists whose research has cross-commodity applications. The entire program is discussed in Area 13. Although much of the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to dried fruits and tree nuts, only a proportional part of that effort has been allocated to Area 3.

Federal effort in this program totals about 18 professional man-years divided as follows: objective measurement of quality 2.0; quality maintenance in handling and packaging 1.5; quality maintenance in storage 3.4; quality maintenance during transportation 1.3; post-harvest physiology 1.8; post-harvest disease control 4.0; and prevention of insect infestation 4.8 man-years. This includes fractional man-year time on contract research, and about one man-year for leadership in the total area.

Work terminated during the period included: handling of McIntosh apples (MQ 2-38); packaging Western peaches (BS 2-55); film liners for grapes (BS 2-59); film liners for pears (BS 2-65); thermostatic control of car temperatures (BS 2-66); control of apple scald (BS 2-84); bulls-eye rot of apples (BS 2-108); control of decay in apples and pears (BS 2-109); fiberboard boxes for apples (BS 2-110); film liners for plums (BS 2-112); brown core of Anjou pears (BS 2-113); transportation of Bartlett pears (BS 2-115); freezing injury to apples in transit (BS 2-117); control of sweet cherry decay (BS 2-118); control of soft scald of apples (BS 2-119); control of decay in peaches for processing (BS 2-132); storage of strawberry plants (BS 2-137); quality measurement of peaches for processing (BS 3-54); and residual sprays and good housekeeping to prevent insect infestation of dried fruit (BS 1-66 Rev.).

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 16.6 professional man-years in this area. These were divided among quality measurement, packaging, storage and transportation studies and research on post-harvest physiology and diseases. Almost half of the research in market quality is shown for the western region with the balance of the program fairly evenly divided among the other regions of the country. No work was reported on insects infesting dried fruit and tree nuts. Industry and other organizations, principally chemical companies and dried fruit and wine companies, conduct limited research involving market quality of deciduous fruits and nuts. In 1961 this effort was estimated as about 7 professional man-years.



## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement of quality

1. Eastern apples. A light transmittance instrument developed for evaluating maturity of apples on the basis of chlorophyll content was given an experimental trial during 1960 in a cooperating grower's packing shed. Several thousand apples of three sizes (Red Delicious and Golden Delicious varieties) were classified into three categories of apparent maturity on the basis of the readings of the instrument. External color difference between these categories were observable with Golden Delicious fruit, but not with Red Delicious.

This fruit then was stored and subjected to several quality determinations at intervals through the storage season, which was about 5 months for Golden Delicious and 8 months for Red Delicious. The laboratory taste panel consistently rated the fruit classed as most "mature" (low chlorophyll) by the instrument as being sweetest. The soluble solids content of this category of fruit was highest also.

The panel rated the Golden Delicious fruit classified as least "mature" (high chlorophyll) by the instrument as being the most acid, but observed no significant difference in acidity among maturity categories of Red Delicious. However, the data on titratable acidity showed no consistent relationship in either variety with maturity category as measured by the instrument. At time of harvest, firmness of all three categories was the same in each variety.

Two large scale taste panel evaluations of preference were made on Red Delicious after 7½ months of storage. The first, made on fruit immediately out of storage indicated that the apples of the least mature category were least preferred. The second evaluation made on fruit held 3 days at room temperature showed no significant differences among the three categories.

After 8 months' storage, Red Delicious classified by the instrument as most mature had most break-down upon holding at room temperature.

The more mature Red Delicious had more water-core than the less mature categories. This is particularly significant since the light transmittance instrument provides a method for detecting this internal defect without cutting the fruit.

In 1961 weekly pickings of Red Delicious and Golden Delicious from young and old trees were separated by light transmittance readings into high, medium, and low chlorophyll, and stored at 32°F. After six months' storage, Golden Delicious fruit of high chlorophyll content

at mid-season harvest had only 1-2% rot as compared to 30% rot for low chlorophyll fruit harvested the same date.

After six months' storage, early-harvested, high-chlorophyll-content, Red Delicious apples had developed about 1% decay. Low-chlorophyll fruit harvested a few weeks later developed about 8% decay in the same period. After one week at room temperature, rots increased to about 4% and about 26%, respectively. Scald development in Red Delicious was most serious in the high chlorophyll fruit. (MQ 3-28)

2. Western apples. A good correlation between light transmittance readings on the difference meter, specific gravity of the individual apples, and the severity of water core, as shown by examination of the cut fruit, was obtained with Starking Delicious and Winesap apples at time of harvest. Difference Meter readings on Starkings made at intervals during storage were consistently higher than at harvest and not reliable as an indication of water core, particularly as browning or discoloration of the flesh developed.

Initial readings of 60 or higher on size 88-125 Starking indicated apples free of water core. Progressively lower readings indicated increased severity of water core. In February, there was considerable browning of the flesh of the apples with initial difference meter readings indicating moderate water core. Most of the fruit with less initial water core had cleared up by February but examination of this fruit in March disclosed 50% breakdown. By May, even the Starkings which had started the storage season with the slightest water core had developed 20% breakdown.

Difference meter readings on Winesaps during storage were more indicative of the intensity of water core. Most of the water core in this variety cleared up without extensive flesh browning. The discoloration that did occur was confined in most cases to the core area.

A "Mechanical Thumb" for determining firmness of apples, which is not destructive to the fruit, was developed at Wenatchee as an attachment to the Magness-Taylor Pressure Tester. The apple tissue involved is about the same area and volume as that bruised by an inspector when he uses his thumb to test firmness so the fruit need not be discarded after testing. (MQ 3-28)

3. Red tart cherries. Anthocyanin pigment development in sound, intact red cherries was evaluated by light transmittance techniques. This was accomplished by measuring the difference in optical density of 540-612 mμ. This value (O.D. 540-612 mμ) correlated highly with the anthocyanin content of the cherries as determined by chemical procedures. However, this reading was affected by the condition of the cherries. Bruised fruit which was held until scalded gave higher readings than fresh, sound cherries. Further experiments indicated that it was



possible to detect and evaluate the extent of scald by light transmittance measurements at longer wavelengths (780 - 695 mu). It is necessary, however, that cherries be evaluated for this type of damage before measurement of their anthocyanin content. This might be done rapidly with a dual purpose instrument without damaging the fruit.

A light transmittance instrument of the direct phototube type was used to sort cherries for scald at  $\Delta OD$ . 740-695 mu and for red pigment development,  $\Delta OD$ . 620-540 mu. Good agreement was achieved between instrument sorted fruit and visual evaluation. Fruit sorted for red pigment were measured by category on a color reflectometer (Hunter CDM) then canned and processed. Low colored cherries (0-30 scale reading by light transmittance) read 126 by CDM color formula, while more highly colored fruit, classes 30-50 read 139, 50-70 read 149, 70-80 read 152, 80-90 read 156 and the highest colored cherries (90-100 scale reading) read 159. Soluble solids determined on representative samples of these lots were 11.6, 13.0, 13.5, 14.2, 15.9 and 16.7 percent, respectively, indicating an additional quality separation. The relationship of scald index and separation for color with fresh and processed product grade is being determined.

An extensive program was undertaken in the Michigan cherry producing area in the 1962 season to relate scald index and red pigment evaluation with fresh and processed product grade. The portion of an inspector's sample graded as usable was further evaluated for scald and red pigment. (MR 3-27)

4. Italian prunes. Juice from a section cut on the side opposite the suture and equidistant from each end of 20 prunes had a soluble solid content approximately that of a composite juice sample from the same fruits. The soluble solids in the suture side were lower than those from other portions and there was considerable variation in solids of the 2 cheeks of the prune.

There was a general increase in the wavelength of peak light transmittance (Hortispect), flesh color (visual rating), and soluble solids (refractometer) with progressive pickings. Hortispect readings did not accurately indicate flesh color. When the flesh and skin were tested separately, the readings on the skin alone were about equivalent to that obtained on the intact fruit, while readings on the flesh alone were at wide variance. Hortispect readings on the flesh of light and dark colored prunes varied from 560 to 570, but varied from 570 to 610 on the skin. The latter readings corresponded closely to readings of the entire fruits. The high concentration of pigment in the skin of the prune appears to have the principal effect on the wavelength of peak light transmittance.



An increase in the wavelength of peak light transmittance occurred in storage at 32°, 36°, and 40° F. The change was most rapid with the higher temperature and was still changing at the end of a month in storage. There was a decrease in soluble solids during storage which was most noticeable in the less mature fruit and at the lower storage temperatures. Flesh firmness and total acid content of the prunes decreased in storage.

Severe flesh browning was encountered in some prunes when they were removed from cold storage and ripened at 70° F. Prunes stored at 36° developed the most browning and those at 32° the least. Dessert quality was poor when soluble solids at harvest were below 14 percent. (MQ 3-38)

5. Peaches. Twelve breeding lines and varieties of peaches were processed for evaluation as purees. Considerable variation was found in color, texture, and soluble solids of the processed product. These findings were of benefit to the plant breeders for the selection of desirable genetic material. (BS 3-54)

#### B. Quality maintenance in handling and packaging

1. Apples. In three truck hauls from orchard to New York City (80 to 100 miles) apples in cell-packed cartons sustained the least bruising. Following in order of increasing damage were fruit in shrink-film overwrapped trays, polyethylene bags, tray layer packs, and jumble-filled packs.

The retail store condition of test lots of McIntosh apples in cell packs, poly bags, and shrink-film overwrapped trays was studied in early 1962. In New York supermarkets, fruit in overwrapped trays had less bruising and puncturing than cell-packed fruit sold in bulk, while poly-bagged fruit had the most bruising and puncturing. After a holding period the amount of fruit decay was greatest in poly bags and least in overwrapped trays. Experimental work has been completed and a manuscript prepared. (MQ 2-38)

Mealy breakdown, one of the most serious disorders of California Yellow Newtown apples held in CA storage, had previously been found to occur in all lots stored at 40° F. in atmospheres of 0 to 10 percent carbon dioxide in combination with 3 percent oxygen. Fruit that was most mature at harvest appeared to be most susceptible to mealy breakdown.

Fruit was harvested on three different dates in the 1960-61 season (Sept. 28, Oct. 6, and Oct. 19) and was stored at 40° F. in atmospheres of 7 or 10 percent carbon dioxide in combination with 3-4 percent oxygen. When removed from storage in mid-June apples from all lots

were crisp and juicy. There was slight carbon dioxide injury in fruit held at 10 percent carbon dioxide. When the fruit was held for 1 week at 70° after removal from storage, 71 percent of the fruit from one orchard and 50 percent from another developed mealy breakdown. The disorder could not be correlated with harvest maturity or carbon dioxide level during storage. (BS 2-68)

To test the accuracy of the RSAVA formula, developed previously for film permeability and respiration equilibrium, 135 bushels of apples were stored at 30-32° F. in polyethylene, polypropylene, rubber hydrochloride, and polyvinyl chloride liners. Results of these tests indicate the respiration rate of the apples were within the ranges predicted in the tables developed from the formula. The permeable surfaces of apple liners were not significantly affected by tying the liner tops, and no correction factor is indicated for this closure. Apple temperatures within liners averaged 0.35° F. higher than in boxes without liners. The shipping container caused no significant difference in either the respiration or firmness of apples stored within liners. Firmness readings after 9½ months' storage in sealed liners indicated the performance of all liners used was satisfactory.

Pallet covers and bulk-box covers made of 2-mil polyethylene were beneficial in retarding moisture loss from Golden Delicious apples but were less effective than individual box liners. With the covers, moisture was still lost to the boxes or through the exposed bottom. In one test with fruit stored 5 months at 32° F. in field boxes, weight losses averaged 5.4% in boxes without liners, 3.4% in boxes stored under a pallet cover, and 1.6% in boxes with polyethylene liners. Visible fruit shriveling was extensive only in boxes without liners. Gas concentrations under the pallet covers and bulk-box covers ranged from 0.4 to 1.1% CO<sub>2</sub> and 19.4 to 20.7% O<sub>2</sub>. Deterioration in the form of splitting followed by decay under the pallet covers was excessive only when fruit was too ripe for late storage. It was worse in top-layer apples in contact with condensation on the film.

Packets of hydrated lime inserted in cartons effectively absorbed excess CO<sub>2</sub> in 6 tests with Delicious, Golden Delicious, Stayman, and McIntosh apples. With no lime in the sealed liners, CO<sub>2</sub> averaged 5-8% during storage. With ½ pound of lime in a waxed paper or kraft paper bag, CO<sub>2</sub> was held near 1% for 2-3 months at 32°, and then climbed rapidly as the lime was neutralized. With 1 pound of lime, CO<sub>2</sub> was effectively absorbed within the liners and averaged less than 1% during 5 or 6 months' storage. Intermediate levels of 2-4% CO<sub>2</sub> were maintained during storage by inclosing cellophane or perforated polyethylene bags instead of paper bags to hold the lime. These restricted the contact of lime with the air more than kraft or waxed paper bags.



The use of lime in film-lined boxes of Red Delicious was beneficial, as the fruit was firmer after storage than that without lime and less scald developed.

Golden Delicious apples were dipped in solutions (1000 and 2000 ppm) of  $C_{16}$  alcohol (cetyl) and  $C_{20}$  alcohol and then stored 5 months at  $32^{\circ}$  F. At the higher concentration the material reduced weight loss during storage about 20% as compared with untreated apples. However, polyethylene liners provided much greater protection from weight loss and shriveling than did the alcohol coatings.

A test to compare the keeping quality of freshly harvested apples stored at  $32^{\circ}$  or  $40^{\circ}$  F. for 1 to 5 months in 4 pound perforated polyethylene bags (12 bags to master carton) or in bulk bushel boxes was initiated in the fall of 1961. Red Delicious and Jonathan apples from three orchards were used for the study. On removal from storage at monthly intervals apples were examined and placed on simulated retail display of either 7 days in a refrigerated case or 7 days at  $70^{\circ}$  F.

The data are not completely analyzed, but it appears that prepackaged apples stored as well if not better than bulk apples, mainly due to less weight loss, shriveling, and decay in the packaged apples. Apples in good condition probably can be safely prepackaged in film bags several months ahead of the time of sale if held in refrigerated storage. Both packaged and bulk apples shriveled more in the refrigerated case than at  $70^{\circ}$ . (MQ 2-63)

2. Peaches. Hydrocooling and warming rates of peaches in 3 common shipping containers: baskets, wirebound crates, and corrugated cartons were studied. With hydrocooling water maintained at approximately  $35^{\circ}$  F., peaches in  $3/4$ -bushel baskets, wirebound crates and corrugated cartons cooled from about  $68^{\circ}$  to  $44^{\circ}$  in 20 minutes. At the end of the hydrocooling period, peaches in the center of baskets and cartons were 3 to 7 degrees warmer than peaches in the top or bottom. The slowest rate of cooling in wirebound crates was in bottom layer fruit.

Peaches cooled to  $54^{\circ}$  F. by hydrocooling in containers before being placed at  $70^{\circ}$ , warmed to a constant temperature in about 18 hours. The rate of warming following hydrocooling was slowest in corrugated cartons and fastest in wirebound crates.

Cartons formed of corrugated board with flutes running at right angles to the flow of water in the hydrocooler retained only one-half the weight of water that was retained by cartons with flutes parallel to the flow of water.



An average of 24 percent of hydrocooled peaches in 3/4-bushel baskets were bruised as compared to 18 percent in boxes of similar capacity when stacked 5-high during simulated transportation to market. Bruising was rather evenly distributed from top to bottom in the stacks of baskets. Within the stack of corrugated boxes, little difference in incidence of bruising was noted in the top four boxes and each box contained less bruised fruit than a basket correspondingly placed in a stack. However, the number of bruised peaches was high in the bottom box of the carton stack, averaging 29 percent bruised fruits as compared to an average 15 percent in the top four boxes.

Bruises on peaches in baskets were more severe than those in boxes. Of all bruises, 35 percent of those found in baskets were greater than  $\frac{1}{2}$ -inch in diameter as compared to 26 percent in boxes. (MQ 2-33)

### C. Quality maintenance in storage

1. Apples. In the 1960-61 season Starking Delicious apples picked at 140, 150, and 160-day intervals after bloom, and stored in controlled atmosphere storage, were slightly firmer at time of removal after 6 months and 8 months of storage than similar fruit held in regular storage at the same temperature. This difference disappeared after a few days at 70°.

The 140-day fruit from regular storage (check fruit) had as high quality as that from controlled atmosphere as judged by a taste panel, but the late-maturity fruit (160 days) was rated higher out of CA storage than the check fruit.

A differential in flesh firmness of approximately 2 pounds existed throughout the storage season between the early maturity and late maturity fruit stored in regular storage and in the CA room maintained at 2.5% oxygen and 0.5% carbon dioxide. Fruit from a room which was maintained at 2.5% oxygen and 5.0% carbon dioxide, softened more rapidly than the other lots when removed to 70° room. The 5% level of carbon dioxide was deleterious, to the fruit.

Fruit removed from controlled atmosphere storage on April 10 and placed in regular 31° storage exhibited the same firmness and total acid content in June as fruit held in CA storage until June. This indicated that the influence of CA storage on these properties was greatest during the fore part of the storage season.

As reported in previous years, the principal distinction found between apples from regular storage and CA storage was the higher acid content in the CA fruit. The acid contents of the 3 maturities at harvest were: 0.285, 0.241, and 0.233 percent. Upon termination of the tests in June, the acid percentages for the regular storage fruit were, 0.142, 0.119, and 0.096; for CA storage with 2.5% O<sub>2</sub> and 5% CO<sub>2</sub>,

0.217, 0.169, and 0.173; for CA storage with 2.5% O<sub>2</sub> and 0.5% CO<sub>2</sub>, 0.185, 0.160, and 0.167, respectively. (BS 2-114)

In the 1961-62 season Washington State Delicious apples were stored in controlled atmosphere rooms in which the oxygen level was lowered to 5% in 10 days, 20 days, and 40 days. No significant differences were found in quality of the fruits from any of these lots as determined by flesh firmness, soluble solids, pH, total acid, or flavor after a full seasons storage. The data indicate that the State Law requiring that oxygen be lowered to 5% within 20 days to qualify apples for a CA label, may be more stringent than necessary.

Fruit from a room with 2.5% oxygen was only slightly firmer than that from the room with 5% oxygen, but the difference was statistically significant. No consistent differences were found for solids, pH, acidity, or flavor, although results slightly favored the room with 2.5% oxygen.

Mealy breakdown of California Yellow Newtown apples after removal from controlled atmosphere storage has been a serious problem in some years. Research was conducted to relate this disorder to (1) the vigor of the tree, (2) the field temperature of the fruit (as affected by northern or southern exposure on the tree), (3) the temperature in storage, and (4) the composition of the atmosphere in storage.

Apples examined after 9½ months' storage had no mealy breakdown or internal browning. However, fruit stored at 38° F. was firmer and greener than that stored at 40°. Apples stored in 6 percent CO<sub>2</sub> and 3 percent O<sub>2</sub> (6:3) were slightly firmer and greener than those stored in a 3:3 atmosphere. Fruit stored in either of these atmospheres was much superior to that stored in a 6:8 atmosphere. Yellow Newtowns held in the latter atmosphere had about 10 percent scald; those in the 6:3 atmosphere had no scald; and those in the 3:3 chamber had only a slight amount in one lot.

After 2 weeks at room temperature, mealy breakdown affected from 6 to 22 percent of the fruit harvested from young vigorous trees and subsequently stored in modified atmospheres. Fruit harvested from old, less vigorous trees was practically free from mealy breakdown. Fruit from the south side of the young trees had about 1.5 times as much breakdown as that from the north side. Slightly less breakdown occurred at 38° F. than at 40°.

Respiration rates taken at 53° F. after the storage period showed that of the apples previously held in the 3 different atmospheres, those in the 6:8 atmosphere respired fastest and those in the 6:3 atmosphere respired slowest. (MQ 2-57)



2. Bartlett Pears. Polyethylene liners are commonly used in L/A lugs for large-size Bartlett pears marketed in the West. Previous work indicated that storage disorders were affected by the degree of ventilation in the liners, and by the maturity of the fruit at harvest. In current studies, fruit was harvested on three dates (Aug. 10, Aug. 17, and Sept. 1) and stored without liners, in sealed liners, or in liners perforated with five pin holes. Fruit from each harvest was stored at 31° F. until December 5 or January 30.

At the first withdrawal from storage (December 5) all fruit from the first 2 pickings ripened with excellent quality and no core browning. Fruit of the third picking developed much more core browning in either sealed or ventilated liners than without liners.

Fruit withdrawn for ripening on January 30 showed a similar trend, but only the first picking ripened without any core browning. The disorder was most severe in the last picking and worse in liners than in containers without film liners. (BS 2-65)

3. Bosc Pears. Bosc pears harvested on September 13 were packed in sealed or multi-perforated polyethylene liners or without liners and stored for 3 or 5 months.

Carbon dioxide and oxygen levels after 3 months' storage were 3.4:16.7 in the sealed liners and 1.3:20.3 in the perforated ones. The atmospheres were about the same after 5 months' storage.

The fruit ripened without internal breakdown after both storage periods. Quality, however, was relatively poor in all lots, the fruit being mealy and lacking juice. The poor quality was not a result of storage conditions, however, since fruit ripened immediately after harvest was also poor. (BS 2-65)

4. Plums. During the 1961 season Santa Rosa plums from two locations in the San Joaquin Valley were stored at 30°, 32°, 36°, or 41° F. for 2, 4, or 6 weeks. The plums were divided into two groups based on appearance. Plums of one group had large, prominent lenticels, which gave them an almost russeted appearance, and those in the other group had small, inconspicuous lenticels, were smooth and uniformly colored. The "russeted" fruit was 2-3 percent higher in soluble solids and superior to the smooth plums in flavor. Keeping quality was not affected by type.

A breakdown associated with overripeness which appeared after 6 weeks' storage was most severe at the two highest temperatures. In a parallel experiment, in which plums were divided into three maturity classes based on color, the only breakdown was in the more mature fruit held at 36° and 41° F.



Three new plum varieties were picked at weekly intervals and the soluble solids content and firmness determined throughout a storage and ripening period. The Nubiana and Laroda varieties, stored for 6 weeks at 32° F., ripened after removal from storage, to good dessert quality if the initial soluble solids content was between 16 and 18 percent. Soluble solids content remained constant during storage. Sound Nubiana plums picked as late as August 16, 3 weeks after the commercial picking date, were still firm enough on October 1 to require 5 to 7 days at 65° F. to ripen. Queen Anne plums had a lower soluble solids content and did not store as well as the other two varieties.

During the 1962 season commercially harvested Nubiana plums were held at 60° F. to determine if they were capable of normal ripening. Two lots averaging less than 15 percent soluble solids did not ripen with satisfactory quality. One lot averaging slightly above 15 percent soluble solids ripened to fair quality.

When Nubiana plums were stored for 7 weeks at 34° F. in sealed polyethylene lug liners, the resulting modified atmospheres (CO<sub>2</sub> 7%, O<sub>2</sub> 11%) reduced decay, prevented ripening in storage, and delayed ripening during subsequent holding at 70°. This modified atmosphere did not produce off flavors, odors, or other harmful effects. (MQ 2-12)

5. Grapes. Emperor grapes were hydrocooled in the packed lug boxes and fumigated with 1.0 or 0.5 percent SO<sub>2</sub> for 20 minutes prior to storage. The half-cooling time was less than 2 minutes. Wet grapes and containers absorbed about twice as much SO<sub>2</sub> as dry grapes and containers. After 3 months' storage, the hydrocooled fruit had less weight loss and slightly less decay than fruit that was cooled in air. Both the stems and berries of the hydrocooled fruit had a better appearance than fruit in check lots, as evidenced by brighter color and less dessication. (MQ 2-49)

6. Dried fruits. In cooperation with the Dried Fruit Association of California a survey was conducted in 1960-61 to compare the quality of dried fruit in retail stores with the initial quality at time of packing. Temperatures and relative humidities were taken in retail stores and the length of time dried fruits remained in marketing channels was determined. A total of 678 packages of dried fruit was carefully examined. Seven percent of the apricot samples, 11 percent of the prune samples, 13 percent of the raisin samples, and 17 percent of the fig samples collected in retail stores were of poor quality because of excessive darkening, insect infestation or other defects. Aging was the primary cause of deterioration, but inadequate packaging and high store temperatures also contributed to excessive deterioration. (MQ 2-9)

7. Strawberry plants. A storage test using  $\frac{1}{2}$  million Catskill strawberry plants was conducted in a commercial storage at Salisbury, Maryland in 1962. The objective was to evaluate the cooling rate of 3 types of packages and 3 stacking patterns. The storage was at  $30 \pm 1^\circ$  F. with forced air circulation for a period of one month. Cooling was substantially slower in solid stacks of containers than in spaced double or single stacks, as would be expected. Plants packed in fiberboard cartons cooled slower than those in standard wirebound crates. (BS 2-137)

D. Quality maintenance during transportation

1. Pears. In cooperation with the California Tree Fruit Agreement shipping tests were conducted during the 1961 and 1962 seasons to determine suitable transit protective services for the initiation of ripening in Bartlett pears during transit to eastern markets.

Modified icing of standard refrigeration cars provided the moderate temperatures needed for initiation of ripening, but the amount of ice required depended on the flesh firmness and temperature of the fruit. Fruit of 19 pounds pressure test or higher, and  $75^\circ$  F. or lower in temperature, required only an ice replenish at the first icing station and one reicing at Chicago. If initial temperatures were warmer ( $75^\circ$  to  $85^\circ$ ) two reicings were needed (Council Bluffs, Iowa and Marion, Ohio) and if above  $85^\circ$  the two reicings were needed earlier during the transit period (Ogden, Utah and Chicago, Illinois). All of these are half-stage services. If the fruit was below 19 pounds at harvest, either full-bunker icing or more reicings at half-stage was needed. If the fruit was mature enough to require pre-cooling, then one reicing was enough (full bunker). This would cost \$80.49 less per car than standard refrigeration.

In test shipments of early-season California Bartlett pears to eastern markets in thermostatically controlled rail cars average transit temperatures near  $60^\circ$  F. were suitable for fruit with initial firmness near 20 lbs. and with loading temperatures below  $75^\circ$ . Average temperatures near  $55^\circ$  were desirable for fruit with initial firmness near 18 to 19 lbs. and with moderate loading temperatures.

Modified, half-stage icing of standard cars was used as a comparison with Ice Tempco and mechanical cars, which have thermostatic control. Shipping pears in a pre-iced car, which was replenished at the first reicing station, and was re-iced twice in transit (Council Bluffs, Iowa and Marion, Ohio) provided average temperatures near  $55^\circ$  F. The pears required about 3 to 4 days' time to ripen after arrival in New York.



Ice Tempco cars equipped with a ceiling duct were found to provide relatively uniform temperatures through the load. Temperatures in cars without a ceiling duct were not uniform. Some mechanically refrigerated cars also had fairly large temperature differences between one end of the load and the other. (BS 2-115)

2. Strawberries. Preliminary tests to compare refrigerated express and freight service from California to Chicago for strawberries indicated that express shipments were slightly superior but that freight service was feasible. Further shipments are required to properly evaluate the two methods of shipping. (MQ 2-20)

3. Grapes. When precooled grapes were fumigated in an Ice Tempco refrigerator car equipped with a ceiling duct, all the fans had to be turned on during the fumigation to obtain reasonably uniform SO<sub>2</sub> concentrations in the load. Following this procedure, maximum concentrations in the space above the load, and in boxes in the "A" and "B" ends of the car were 0.6, 0.3, and 0.4 percent, respectively. When only the by-pass fans were operating, comparable SO<sub>2</sub> concentrations were 1.2, 0.03, and 0.8 percent. The doors or hatches had to be opened to remove the SO<sub>2</sub> from the car in a reasonable time. (MQ 2-49)

4. Blueberries. Forced air cooling of packaged blueberries showed that in commercial pallet load quantities (78 to 156 crates of 12 pints each) half cooling times of about 1 hour or less were possible with air movement of about 4 c.f.m. per pint or about 2 hours with air movement of about 1 c.f.m. per pint. Forced air cooling was four or more times faster than that currently obtained by conventional methods of room cooling.

Increasing the amount of nitrogen fertilizer applied during crop development decreased fruit acidity, soluble solids, dry weight and keeping quality and increased total yield slightly. Fruit with less than 0.6% acid or a pH higher than 3.25 at harvest did not keep as well as fruit with more than 0.6% acid or pH values below 3.25. (MQ 2-4)

5. Simulated transit in nitrogen atmospheres. Peaches developed a fermented flavor when held in 100% nitrogen at 60° F. for 4 days or longer, but remained normal in flavor when held in 99% nitrogen at the same temperature with 1% oxygen for periods up to 10 days. Little softening occurred in fruits held in 100 percent nitrogen as compared to that occurring in fruits in 99 percent nitrogen or in normal air. Development of Rhizopus and brown rot of peaches was prevented in 100 percent nitrogen and retarded in 99 percent nitrogen.



The growth of mold was prevented on strawberries held at 33° F. in 100% nitrogen, but not in 99% nitrogen with 1% oxygen or in normal air. Berries held in 100% nitrogen softened more rapidly than in the other atmospheres. Strawberries held in 99 or 100% nitrogen kept as well after removal to normal air as fruit held continuously in normal air. Flavor of strawberries was not affected by holding the berries in 100% nitrogen at 33° for periods up to 10 days.

Growth of *Penicillium digitatum*, *Botrytis cinerea*, and *Sclerotinia sclerotiorum* in vitro was inhibited in 100 percent nitrogen but not in 99 percent. Growth of *Phomopsis* spp. was retarded in 100 percent nitrogen. (M 2-71)

#### E. Post-harvest physiology

1. Apple scald. During the year the Food and Drug Administration granted clearance for use of diphenylamine (DPA) to control apple scald with a residue tolerance of 10 p.p.m. on treated fruit. This action culminated 6 years of evaluating DPA on various varieties and obtaining toxicological data to determine its safety. Apples may now receive a postharvest dip or spray in 1000-2000 p.p.m. wettable powder suspensions of DPA, be wrapped in DPA impregnated tissue paper, or receive a pre-harvest spray of DPA within a day or two of harvest. The pre-harvest sprays are less effective than postharvest treatments. Another scald inhibitor, ethoxyquin, was cleared for commercial use in 1960.

Fourteen tests were conducted to compare effectiveness of various application procedures for DPA and ethoxyquin on eastern apples. On early picked Delicious and Rome apples, considerable scald developed even on the treated lots, indicating that care in selecting a picking date will continue to be important. The use of wettable powder formulations of DPA may require higher treating concentration than alcohol suspensions of DPA, to obtain the same scald control. Suspensions of DPA and ethoxyquin heated to 120° F. and used as a 5-10 second dip usually gave better coverage and better scald control than 60° treatments. A 2-week delay after harvest before treating markedly reduced the effectiveness of both scald inhibitors. Spraying fruit in field boxes with scald inhibitors gave nearly as good scald control as dipping. Golden Delicious were not injured by dipping in 2700 p.p.m. ethoxyquin or 2000 p.p.m. DPA in wettable powder form.

Dipping Red Stayman apples in warm water (30 sec. at 140° F. or 60 sec. at 130°) soon after harvest controlled scald as well as treatment with DPA, but Red Delicious, Grimes Golden, Winesap, and York were severely injured by the heat treatments.

DPA treated molded-pulp trays and DPA treated polyurethane layer pads, made by soaking in 4000 p.p.m. DPA suspensions before use, provided good scald protection for Stayman apples. However, the treated polyurethane pads caused severe skin injury.

Stayman apples from 3 different pickings were separated by light transmittance techniques into 3 groups based on internal chlorophyll content. There was no relationship between internal chlorophyll and subsequent scald development at any one picking. Grading apples by light transmittance does not appear to be a promising method of pre-determining scald susceptibility. DPA dip treatments provided the most complete scald control on late pickings. (BS 2-84)

2. Apple respiration in modified atmospheres. Instrumentation problems have delayed progress of this PL 480 project. However, sufficient data have been obtained to show that the presence of above normal concentrations of CO<sub>2</sub> in the storage air depresses the output of carbon dioxide from apples less than it does the uptake of oxygen. Respiration determinations at five temperatures from 32° to 45° F. in normal air showed that both carbon dioxide output and oxygen uptake more than doubled with a 13° F. rise in holding temperature. (E29-AMS-1(a)).

3. Anjou pear scald. Anjou pears harvested in the Wenatchee Valley at 140, 145, 150, and 160 days after full bloom were dipped in a suspension containing ethoxyquin and then wrapped in plain paper wraps. Untreated samples were wrapped in plain paper and in oiled basic copper sulfate paper. The fruit was packed in perforated polyethylene liners and stored at 30° F. until mid-April. Scald and decay counts were made after a ripening period of 7 days at 70°. Results showed substantial scald and decay control with both treatments, as compared with the control, but considerably better decay control was obtained with the oiled basic copper sulfate wrap than with ethoxyquin. (MQ 2-66)

4. Brown core of pears. Contract research at Oregon State University confirmed previous findings that early-picked Anjou pears showed only a slight amount of brown-core development. However, in fruit picked at mid-season during 1961 considerably more brown-core occurred than in previous seasons. Slow cooling did not increase severity of brown-core, but a delay of 4 days at 70° before storage caused more injury. Low oxygen tends to increase severity of injury.

Anjou pears from low vigor trees developed more brown-core than those picked the same day from high vigor trees. Fruit from the high vigor trees were firmer at harvest indicating that they were less mature.

Fruit with brown-core has consistently shown high succinic acid concentrations in the injured tissue.



Promising results in maintaining desired CO<sub>2</sub> concentrations in sealed film liners were obtained by the use of lime in various types of paper bag. A pad made of waxed Kraft appears promising. (BS 2-113)

5. Blueberries. The relation of fruit-leaf ratios and temperature during the harvest season to several fruit quality factors were measured with blueberries from plants grown on nutrient solutions in the greenhouse. High temperature during this period decreased fruit acidity. Fruit-leaf area ratios were related to soluble solids, rate of ripening, and to acidity to some extent. Keeping quality decreased noticeably toward the end of the harvest period for fruit from each bush indicating this same response noted in field tests is associated in some way with the physiology of the plant. (M 2-4)

6. Leucoanthocyanins and astringency in peaches. In earlier studies a number of polyphenolic compounds were identified in Elberta peaches of various maturities. One of these groups of compounds, leucoanthocyanins, has been found to have a small water insoluble fraction associated with the vascular elements or transporting tissues within the fruit. Leucoanthocyanins are probably responsible for a major portion of the astringency in peaches but no appreciable change from the soluble to insoluble form was found during ripening. (Pioneering Laboratory Project)

7. Mitochondria and other particles in apple cells. Further studies with apple mitochondria have shown that cytochrome oxidase and DPNH cytochrome c reductase activities can be demonstrated in the particles if careful pH adjustments and other protective measures are taken. Several of the cytochromes have been identified in low temperature spectra of these particles. These activities are in addition to the earlier demonstrated Krebs cycle acid oxidations and provide a means for a basic study of respiratory mechanisms. Work is continuing with various particles isolated from apples and other tissues and their production of ethylene and related gases. A natural emanation from fruit has been found recently that inhibits ripening. (Pioneering Laboratory Project)

8. Mode of action of diphenylamine (DPA). The effectiveness of DPA for controlling apple scald has been shown by experiments in many laboratories but its mode of action has been almost entirely unknown. DPA inhibits the cytochrome electron chain of isolated particles in a region differing from the effect of other classical inhibitors of respiration such as azide and antimycin A. Two compounds besides DPA have been found to have a similar effect on the electron transport chain. These are N-para-tolyl-1-naphthylamine and N-phenyl-beta-naphthylamine. One of these compounds has already been shown by another laboratory to be effective in controlling apple scald. (Pioneering Laboratory Project)



## F. Post-harvest disease control

1. Apples. Work was continued on the assay of pectin-splitting enzymes of Penicillium expansum, Neofabraea perennans and Botrytis cinerea. Culture filtrates of the three organisms grown on a straight synthetic medium and on a synthetic medium containing 50% apple juice reduced the viscosity of pectin solutions. The juice from apples rotted by Penicillium also reduced the viscosity of pectin solutions, while that from apples rotted by Botrytis did not. Optimum pH for enzyme activity of culture filtrates of Penicillium was pH 4.0, while the optimum for the juice from rotted apples was pH 6.0. Optima for Botrytis and Neofabraea were pH 3.0.

A heat-labile, non-dialyzable factor which increased the viscosity of pectin solutions was detected in the juice from apples rotted by Botrytis cinerea. The exact nature of this factor is unknown, but its presence may explain the difference in the texture of apples rotted by this organism, and that of apples rotted by Penicillium expansum. (BS 2-108)

Three commercial lots of captan were used to determine the nature of the chemical injury previously reported on Winesap apples. Injury, resembling storage scald, occurred only on fruit treated with the captan from the same source as that which caused the injury the previous year. The amount and intensity of injury increased in fruit that was treated later in the season. Apparently an impurity in this particular lot of fungicide is responsible for the injury.

Mixtures of captan, SOPP (sodium orthophenylphenate), and DHA-S (sodium salt of dehydroacetic acid) with either diphenylamine (DPA) or ethoxyquin reduced the scald inhibiting properties of the latter two materials. Thirty-one percent of the fruit treated with the mixture of DPA and ethoxyquin exhibited chemical injury. Fruit finish was poor on fruit treated with SOPP or DHA-S combined with either of the scald inhibitors. In view of the foregoing problems with mixtures of fungicides and scald inhibitors, it appears that the application of these materials will have to be a two-step operation in which the fungicide treatment will have to be followed by a clear water rinse before the scald inhibitor is applied. (BS 2-109)

2. Peaches. The concentration of Dowicide A was reduced from 0.09% to 0.06% during  $1\frac{1}{2}$  hours of hydrocooling in a pilot scale ice-refrigerated, flood-type hydrocooler. The pH of the solution also changed from pH 11.6 to 10.7. When solutions containing 0.1% Dowicide A and adjusted to pH 11.5 were frozen and the ice thus obtained was used to hydrocool peaches for  $1\frac{1}{2}$  hours the concentration of Dowicide A remained almost constant and pH was reduced only to 11.2.

Reduction of *Monilinia* (brown rot) or *Rhizopus* decay by this chemical was erratic. Earlier experiments showed that concentrations of 0.05% and lower of Dowicide A were relatively ineffective in reducing post-harvest peach decays. Maintaining the concentration of this chemical in hydrocooling solutions at approximately 0.1% through the use of ice containing the chemical gave effective decay control when the fruit was inoculated shortly before treatment. Erratic decay reduction of peaches with natural infection was considered to be due to the failure of the chemical to reach incipient infections.

The chemical 2,6, dichloro-4-nitroaniline was extremely effective in reducing both *Monilinia* and *Rhizopus* decay either when the fruit was freshly inoculated or when inoculated 24 hours before treatment. It had a static effect on *Monilinia* infections limiting the infections to small spots. It almost completely prevented *Rhizopus* infection.

During the 1961 season hot water treatments were shown to adversely affect organisms on the surface of the fruit and even after penetration below the skin. *Rhizopus* and *Monilinia* decays of peaches were almost completely absent after 2 days holding at 70° F. when freshly inoculated fruit was submerged for 7 minutes in 120° water, 3 minutes in 130° water or 2 minutes in 140° water prior to placing at 70°. A high percentage of the fruit was still sound after 8 days at 70° whereas the check fruit, (dipped in room temperature water) was almost completely decayed after 4 days at 70°. When hot water treatments were applied 24 hours after inoculation they were equally as effective in reducing decays as with freshly inoculated peaches. Temperatures just under the skin after hot water treatment ranged between 105 and 115°. Pit temperatures usually were 5 to 10° higher than the original temperature of the fruit. Treated fruit with 95° pit temperatures was cooled in a flood-type hydrocooler to below 50° in 20 to 25 minutes. Hot air treatments in which the temperature just under the skin reached approximately 105° were not as effective in reducing decay as hot water treatments.

Continued research with hot water dips in 1962 showed them to be effective in reducing both *Monilinia* and *Rhizopus* decay of peaches during subsequent holding at 70° F. Dips for 1½ minutes in 130°, or 3½ minutes in 120° water reduced *Monilinia* decay as effectively as 3 and 7 minute dips respectively, but were slightly less effective in reducing *Rhizopus* decay. Limited data show that when peaches are transferred to 50° F. immediately after heating in 120° or 130° water or hydrocooled and held at 50° after heat treatment, *Monilinia* decay is reduced as effectively as when peaches are placed at 70° immediately after heating. *Rhizopus* decay however, was higher when peaches were hydrocooled. Much of the *Rhizopus* decay is believed to be due to contamination from the container. Injury sometimes



occurred when peaches were hydrocooled after heating. Injury was not evident when peaches were hydrocooled to about 65° rather than 50°.

Hot air (130° F.) reduced both *Monilinia* and *Rhizopus* decay of peaches, about as effectively as hot water, but required longer exposure. Air with 80, 90, or 95 percent relative humidity was somewhat more effective in reducing decay than air at 35, 50, or 60 percent relative humidity. At the higher relative humidities in 130° air peaches heated more rapidly and to higher temperatures than in 130° air at the lower relative humidities.

When peaches partially decayed by *Monilinia* or *Rhizopus* were heated in hot water the organisms near or on the surface were killed or severely weakened. Spores from the surface of treated peaches did not germinate when streaked on agar plates, and no growth occurred from isolations made about  $\frac{1}{4}$  inch under the peach skin. Growth did occur, however, from about 80 percent of the isolations made from decayed flesh near the peach pit.

*Rhizopus* spores on swab sticks were killed more rapidly at 120° or 140° F. when the relative humidity during exposure was 80 or 90 percent than when the relative humidity was 50 or 70 percent. (MQ 2-22)

Preliminary trials with Southland peaches inoculated with brown rot (*Monilinia fructicola*) indicate disease control by gamma irradiation is dependent upon dose rate. Within the range of 157,000-210,000 rads an average fast rate of 22,000 rads/min. was more effective than an average rate of 2,200 rads/min. The fast rate within the range of 157,000-182,000 rads was as effective as the slow rate at 210,000-250,000 rads. Injury to the fruits was not affected by dose rate. (MQ 2-32)

A fruit rot of Indiana peaches not previously observed on peaches in the Chicago market was investigated. The decay is characterized by light-brown to brown-circular to irregular areas on the surface of the fruit. The fruit retains its shape and the decay, which may extend to the pit, is fairly firm in texture. Isolates made from the advancing area of the decay yielded an organism which appears to have the cultural and morphological characteristics of Phytophthora sp. (MQ 2-64)

To complete the study of *Rhizopus* decay in peaches for processing the rate of growth of *Rhizopus stolonifer* was compared at 10 degree temperature increments between 40° and 90° F. Growth rates on culture media were highest at 70° F. and lowest at 40° and 90°. Growth of the organism on peaches was highest at 86° and higher at 90° than at 70°. (BS 2-132)



3. Grapes. The distribution of sulfur dioxide during the fumigation of grapes in railway refrigerator cars and cold storage rooms was studied in an effort to improve decay control and reduce injury to the fruit.

Although uniform gas distribution had been obtained previously in the two-bunker Carotemp experimental car, poor distribution of gas was obtained in the new single-bunker "Ice Tempco" cars. Using the by-pass fan during the fumigation, the maximum concentration of gas in a lug box of grapes in the middle layer, quarterlength position, in the end of the car opposite the bunker was 0.2 percent, compared to 0.3 percent in a comparable position in the end next to the bunker. The maximum concentration in the space above the load was 1.2 percent. In a car loaded with grapes in a different container, the TKV lug, the maximum concentrations of  $\text{SO}_2$  in the two respective positions were 0.07 and 0.37 percent. Use of all the car fans after the fumigation did not exhaust the gas satisfactorily.

A common commercial practice is to fumigate grapes in conventional refrigerator cars without fans to distribute the gas. The gas is usually left in the cars until they are "pulled" from the shed. Gas concentrations under these conditions were found to be very uneven and 0.1 percent  $\text{SO}_2$  was detected 3 hours after the start of the fumigation. The grapes in the top layer of this load were injured.

A cold storage room fumigated with a calculated 0.25 percent concentration of  $\text{SO}_2$  had the calculated concentration of gas in the space above the stacked fruit, but only 0.17 percent gas in the channels between boxes on a pallet, and no measureable amount in the center of the box. The type of grape containers, the tightness of the pack, and the type of lid affected the concentration of gas within the box.

Grapes inoculated with Botrytis spores were treated with sulfur dioxide after various incubation times. Within 6 hours after inoculation and incubation at 68° F. and saturated RH, exposure to 100 p.p.m. sulfur dioxide at 95 percent RH for 12 minutes effectively controlled decay. Fumigation with the same dose at 58 percent RH did not reduce decay. After a 20-hour incubation period exposure of the grapes to 2,000 p.p.m. for 30 minutes reduced the decay from 96 percent to 53 percent.

Alternaria spores were found to be more resistant to sulfur dioxide than Botrytis spores, but like Botrytis, the sulfur dioxide was much more toxic in the presence of water. The germination of wet Alternaria spores was completely inhibited by exposure to 400 p.p.m. sulfur dioxide for 2 minutes or 100 p.p.m. for 20 minutes. Fumigation with 1,000 p.p.m. at 90 percent RH for 12 minutes and with

4,000 p.p.m. at 80 percent RH for 10 minutes was required for complete inhibition of germination. (M 2-49)

4. Pears. A gamma dose range of 125,000-150,000 rads was effective for gray mold control on both Bartlett and Anjou pears. In the range of 100,000-150,000 rads, a fast dose rate of 25,000 rads/min. was more effective in disease control than 2,500 rads/min. in Bartletts, and less so in Anjous. Doses of 200,000 rads either delayed or prevented normal ripening in both varieties. 25,000 rads/min. was more injurious than 2,500 rads/min. with Bartletts but not with Anjous. Irradiated, slightly unripe fruit of each variety ripened normally at 76° F. regardless of dose. Irradiated hard-green fruit did not ripen normally after exposure to a dose of 200,000 rads. (M 2-32)

5. Cherries for Brining. Cherries were inoculated with Cytospora leucostoma, Penicillium expansum, Aspergillus niger, Rhizopus stolonifer, Botrytis cinerea, and Monilinia fructicola. After approximately 1/2 of each fruit had rotted, sound and rotted cherries were brined together. Sound cherries brined with fruits rotted by C. leucostoma, P. expansum, and A. niger softened in the brine. Juice squeezed from cherries rotted by the 6 organisms was stored in a freezer. Pectin splitting enzymes were detected in all of the preparations except from fruit rotted by M. fructicola. The pectin splitting enzymes in the juice of fruit rotted by B. cinerea and R. stolonifer were largely inactivated by holding at room temperature (75°) for 72-96 hours. The enzyme from R. stolonifer was inactivated further when incubated in the presence of bisulfate brine at room temperature. There was little or no loss in the activity of enzymes in the juice of fruits rotted by C. leucostoma, A. niger, or P. expansum under the same conditions. (M 2-16)

6. Strawberries. Studies on the use of sulfur dioxide fumigation for control of decay in strawberries were continued. Exposure to concentrations of 200 to 400 p.p.m. for 20 to 30 minutes reduced decay to about one-half the levels observed in comparable untreated lots held for the same time. Very little injury was observed at these concentrations. Sulfur dioxide delayed the development of decay for about 24 hours.

In a preliminary experiment, holding strawberries at 32° F. for 5 days reduced the amount of Rhizopus decay that developed during a subsequent 3-day period at 68° F. but Botrytis decay was increased. (M 2-20)

Additional studies on the effect of 32° F. storage on subsequent development of Rhizopus decay did not confirm the preliminary results. No consistent reduction in decay was obtained during 2 days at 65° following the low temperature holding. (M 2-20)



Sparkle strawberries were treated with post-harvest dips of Harven (dehydroacetic acid) and Botran (2, 6-dichloro, 4-nitroaniline) to test the effectiveness of these substances in reducing post-harvest spoilage. The Botran treated berries had the least spoilage followed in decreasing order by Harven, dry control, and wet control.

Botran or Thylate field sprays on 1-year-old Potahantas or Sparkle strawberry beds did not reduce postharvest fruit decay due to Botrytis or Rhizopus regardless of the time and number of spray applications. However, when Botran was used as a postharvest dip at 200 p.p.m. decay was reduced.

Exposure of strawberries in boxes to hot air (110° F.) for 1 hour reduced postharvest decay as much or more than the Botran dip. Decay reduction was better when the relative humidity of the air was 90 percent or higher than when it was 60 percent. Slight scalding of the fruit sometimes occurred. A 7 minute dip in hot water (110°) also reduced decay but caused a medium surface scald on some fruit. The heat injury was more severe when Botran was added to the hot water.

The senescence inhibitor, N<sup>6</sup> benzyladenine, was tested as a post-harvest dip of 20 and 50 p.p.m. on Pocahantas strawberries. After 4 days at 50° F. plus 2 days at 70°, the chemically treated berries were no better in appearance or condition than the non-treated. (M 2-45)

Leather rot (Phytophthora cactorum) and Rhizoctonia brown rot (Rhizoctonia sp.) are two diseases occasionally observed in the Chicago market on strawberries from the southeastern states. California strawberries examined this summer showed small percentages (.5 to 2.0) of each of these diseases. There are no previous records of the occurrence of these two disorders on California strawberries arriving on the Chicago market. (M 2-64)

7. Cranberries. Film liners and CA storage -- CA storage tests were continued for a second year. In this year's study the relative humidity of the CA chambers was regulated as well as the CO<sub>2</sub> and O<sub>2</sub> levels. None of the controlled atmospheres offered commercial possibilities for increasing storage life beyond that attainable in normal atmosphere. Fruit stored in sealed polyethylene liners decayed more rapidly than that in any other treatment. None of the CA treatments damaged the flavor of cooked fruit.

The effectiveness of a series of hot water and fungicide dip treatments on reducing spoilage of cranberries were evaluated. Water temperatures of 125°, 120° and 70° F. were tested. The fungicides tested were the sodium salt of dehydroacetic acid and Botran



(dichloronitroaniline). A delayed treatment and the effect of fluctuating storage temperatures were also studied. Examinations after 3 and 5 months in storage at 38° showed that none of the treatments reduced spoilage below that on control lots.

A supplemental test was included in which half of a lot of healthy berries were inoculated with cranberry pathogens and half were not. Samples of these were treated by dipping in water at 50° (controls) or 125° F. After a holding period at 38° isolations were made from spoiled berries from each lot. Growth of cranberry pathogens occurred in 75% of the isolates made from the controls and in only 6% of those from the 125° dips. The hot water treatment apparently reduced spoilage due to microorganisms but not that due to physiological breakdown. (M 2-45)

8. Pesticide Residues. Under a PL 480 project in Finland a detailed study is being made of captan and malathion residues on fruits and vegetables as a result of different post-harvest applications of these materials. Results to date show that captan has a rather prolonged residual effect, but that such residues on fresh products can be easily removed by surface washing and disappear practically completely in preservation processes.

Malathion, on the other hand, has a very limited residual life even on fresh produce. Its low toxicity and high disappearance during processing are advantageous from a safety standpoint. Both captan and malathion appear to be quite safe for post-harvest use; one for the reduction of post-harvest decay and the other for the control of insect contamination. (E8-AMS-1 (a))

9. X-ray Detection of Fruit Diseases. Under a PL 480 project in Italy an investigation is being made of the usefulness of X-rays for detecting disease in fruit and the pathological changes taking place in the intact fruit. No experimental data are available yet. (E15-AMS-4 (a))

#### G. Prevention of insect infestation

1. Basic Biology and Ecology. A great deal has been learned about the ecological and environmental factors influencing the behavior, flight, and distribution of several species of drosophila in the San Joaquin Valley of California. It has been learned this insect is able to fly as much as 6.4 miles in 2 1/2 hours rather than a few hundred yards as formerly believed. This emphasizes the infestation hazard involved for maturing grapes and figs, as well as for wineries and dried-fruit processing plants, by the close proximity of cull fruit dumps and decaying produce or harvest waste in the fields. Other information obtained will aid in developing practical preventive and control measures. (M 1-5)

2. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area although much of the work is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

3. Insecticidal Control. Several insecticides were applied to growing grapes to evaluate their effectiveness in controlling drosophila infestations. Infestations result in, or accompany, a microbiological breakdown called bunch rot. These tests showed that vineyards dusted with dimethoate or malathion at the rate of 35 pounds per acre produced more grapes, if treated before bunch rot appeared. Two treatments of naled dust applied at the rate of 50 pounds per acre gave better control of drosophila than three treatments of 35 pounds per acre for a similar 3-week period. (M 1-5)

Several insecticides were evaluated against drosophila and the dried-fruit beetle in cull-fruit-dump breeding areas. Granular formulations were not effective when sprinkled on piles over 24 inches deep. However, on piles of less depth, 5-percent heptachlor, 4- and 10-percent malathion, or 2-percent endrin gave good control for 2 weeks. The application rate was 8 pounds of granules per 100 cubic feet. Six pounds of 5-percent granular malathion mixed throughout a 100-cubic-foot, or one-ton mass gave good drosophila control. Three chemicals in wettable-powder form gave good control when mixed with water and sprinkled on the piles at the rate of 8 gallons per 100 cubic feet. These were Guthion (1 lb. of 15-percent), Dylox (1 lb. of 50-percent), and Eayer 29493 (0.5 oz. of 47-percent). (M 1-5)

Drosophila are attracted to wineries in large numbers during the summer months. Methods of prevention and control have been evaluated. Installation of 24x24 mesh hardware-cloth screening and painting it and all window frames with a malathion emulsion is effective in excluding and killing many of the flies. Evaluation of aerosol applications of synergized pyrethrum or DDVP disclosed that a single treatment with the latter was effective for 3 to 5 days, while it was necessary to use pyrethrum as often as twice daily. (M 1-5)

While grapes are drying on paper trays in the field and when raisins are placed in storage they are subject to attack by several species of insects. Results of exploratory tests indicated that malathion-treated drying trays offer protection against the live infestation that originate during the drying period and that would otherwise be carried into storage. It was also found that the malathion residues imparted to the raisins from the treated trays were sufficient to protect the raisins against insect infestation during at least 5 months of storage while awaiting processing and packaging. (M 1-5)

4. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

5. Insect-Resistant Packaging. As with insecticide evaluation and residue analysis, the cross-commodity packaging work at Savannah, Georgia, is reported in Area 13.



PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

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Quality Maintenance in Handling and Packaging

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- Hardenburg, R. E. 1961. Film liners and keeping quality of fruit. Proc. Conference on Factors Affecting Fruit Condition. Rutgers Univ. (BS 2-95)
- Hardenburg, R. E. and Anderson, R. E. 1961. Polyethylene box liners for storage of Golden Delicious apples. USDA MRR 461. (BS 2-95)
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- Olsen, K. L., Patchen, G. O., and Schomer, H. A. 1960. Cooling rates of apples packed in fiberboard boxes as influenced by vents, perforated trays and stacking pattern. Proc. Wash. State Hort. Assoc., 56, pp. 214-220. (BS 2-110)
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- Harvey, J. M., Uota, M. and Kaufman, Jacob. 1962. Thermostatic temperature control for shipments of early-season Bartlett pears. USDA AMS 476. 19 pp. (BS 2-115)
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- Harvey, J. M. 1961. Transit temperatures for early-crop Bartlett pears. Produce Marketing 4(6), pp. 27-29. (BS 2-115)

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- Simmons, Perez. 1960. Escape of methyl bromide through wallboards. *Journal Economic Entomology* 53(5), pp. 968-969. (MQ 1)
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AREA NO. 4 GRAIN -- MARKET QUALITY

Problem. Grain and cereal products are subject damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of micro-organisms, and by the attack of more than 50 species of stored-product insects. Safe storage of grain, flour, and cereal products for extended periods is a problem of immediate concern to military and civilian defense agencies. To maintain the quality of these products, more precise information is needed on the changes that occur in handling, storage, and transportation of these materials and of the products manufactured from them. To insure uniform and standardized products in the marketing channels and more equitable prices to all concerned, new and improved methods and techniques for measuring quality factors need to be developed for use in the inspection, grading, and standardization procedures. There is urgent need for more effective methods for preventing insect damage and contamination during storage, handling, processing, packaging, transportation, and retail distribution. The need is critical for effective pesticides and application methods that can be used in the marketing channels without leaving objectionable residues. Even more desirable is the development, wherever possible, of effective preventive and control measures utilizing biological, physical, mechanical or other non-chemical means that would reduce or completely eliminate the application of pesticidal chemicals.

USDA PROGRAM

The Department has a continuing program involving chemists, engineers, and plant pathologists in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of cereal grains. The research is conducted at Beltsville, Md., and Watseka, Illinois, and also by research contract with Shuman Laboratories, Battle Ground, Indiana and with Doty Laboratories, Kansas City, Mo.

The program includes the following foreign projects under PL 480: A grant to the Israel Institute of Technology, Haifa, Israel, provides for a study to develop quality tests for cereal grains and feeds. Its duration is 4 years, 1960-1964, and involves PL 480 funds with a \$103,785 equivalent in Israeli pounds.

A grant to the Agricultural Higher School, Poznan, Poland, provides for a study of the effect the microflora of wheat flour on its stability, biochemical, and technological properties. Its duration is 4 years, 1961-1965, and involves \$13,091 equivalent in Polish zlotys.

Also there is a continuing long-term program involving entomologists and chemists engaged in both basic and applied research on problems of insect infestation, damage, and contamination of grains and cereal products in the marketing channels. The work at Manhattan, Kansas, and Tifton, Georgia, is in cooperation with the respective State Agricultural Experiment Stations. The work at Manhattan, Kansas, Savannah, Georgia, and Watseka, Illinois, is in cooperation with the Agricultural Stabilization and Conservation Service

and one man-year of effort is supported at each of these locations by Commodity Credit Corporation funds. There is cooperation with growers cooperative associations at Manhattan and with various industry groups at all locations. There is also overall cooperation with the State Experiment Stations in Regional Project WM-16, "Maintaining Grain Marketability by Insect Control in Storage."

The work at Savannah, Georgia, has cross-commodity application. The entire program is discussed in Area 13. Although almost all the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to the insect problems in grain and cereal products, only a proportionate share of the man-power has been allocated to Area 4.

Contract research includes work with the University of Georgia, Athens, Ga., and with Auburn University Agricultural Experiment Station, Auburn, Alabama.

A contract with the Hebrew University in Rehovot, Israel, provides for extensive studies on the effect of ethylene dibromide-fumigated feed on domestic farm animals. It became effective in September 1961 and continues for 3 years. It involves PL 480 funds equivalent to \$98,197.

Another contract with the Hebrew University at Jerusalem, Israel, is for a study of the influence of environmental conditions on the population dynamics of the khapra beetle. It became effective in October 1961 and continues for 3 years. It involves PL 480 funds equivalent to \$44,296.

A contract with the Ministry of Food and Agriculture, Karachi, Pakistan, is for the evaluation of insecticides applied to bulk stored grain as control or preventive measures against the khapra beetle. It became effective in 1962 and continues for 5 years. It involves PL 480 funds equivalent to \$79,570.

A contract with the Administration of Agricultural Reserves and Surpluses, Montevideo, Uruguay, is for the study of underground storage of corn in air-tight silos in relation to maintaining quality and preventing insect infestation during long-term storage. It became effective in May 1962 and continues for 5 years. It involves PL 480 funds equivalent to \$59,906.

The Federal scientific effort devoted to research in this area totals 27.2 professional man-years. Of this number, 7.3 is devoted to quality maintenance and evaluation; 2.4 to basic biology and ecology, 2.4 to insecticide evaluation, and 1.2 to insecticidal control at Manhattan, Kansas; 1.0 to insecticidal evaluation at Tifton, Georgia; 1.0 to insecticidal control at Watseka, Illinois; 2.8 to insecticide evaluation, 2.0 to insecticide residue analysis, and 2.6 to insect-resistant packaging at Savannah, Georgia; 2.3 to program leadership at Beltsville, Maryland; and 2.2 to contract research.

There has been an extensive modification of the research program on stored-grain insects during the reporting period. Previous work has been almost exclusively of a practical or applied nature. In a critical evaluation of the program, it became apparent that some of the work was being impeded by the lack of foundation information of a basic nature. Because of the serious



lack of basic information on the biology, behavior, ecology, physiology, and nutritional requirements of stored-grain insects, it was decided there should be a shift of program to some of these lines as rapidly as possible, without eliminating necessary applied studies.

Sixteen line projects have been discontinued during the reporting period, most of them as a result of shift in emphasis of program. These were: protective treatments for grain (BS 1-34, BS 1-61, and BS 1-44(C)); grain fumigation studies (BS 1-35, BS 1-36, BS 1-60, and BS 1-87); insect control in country elevators (BS 1-40, BS 1-41, and BS 1-42); study of dermestid beetles in grain (BS 1-43); insect problem in corn and oats in the Southeast (BS 1-58 and BS 1-59); an evaluation of the thermal aerosol application of insecticides to stored grains (BS 1-83); deterioration of dry beans during marketing (BS 2-160); and fat acidity as an index of soundness in grain (BS 3-55).

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported work on market quality of grain, rice, feed, and seed as a unit. The combined professional man-years for the unit was 23.4. Of this 9.6 was on objective measurement and evaluation of quality, 0.8 handling and packaging, 2.5 storage, 0.1 transportation, 5.8 post-harvest physiology, and 4.1 insect control.

Industry and other organizations conducting research on these products included large milling companies on milling and baking properties, on storage and handling, and on insect control; feed companies on blending feed ingredients, particularly micronutrients, and on sampling procedures; seed companies on seed germination, seed vigor, and seed quality measurements; and chemical companies on synthesis, development, and formulation of new pesticides and fumigants. Total estimated annual expenditures were equivalent to approximately 28 professional man-years, or about 10 man-years for grain alone.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement and evaluation of quality.

1. Test for Heat Damage in Corn. Increased artificial drying of corn has resulted in quality problems such as increased friability in handling and impaired usefulness for wet or dry milling. In the search for a quick test for heat damage, many chemical and physical methods have been investigated. An inverse relationship between reducing-sugar content and drying temperature (120°-200° F.) was found in four of the five sample groups studied. In all samples, diastatic activity decreased with increase in drying temperature. Statistical analysis of all samples yielded a highly significant correlation of diastase activity with temperature. However, the data indicated that the technique could not be used in its present form in assaying heat damage. Shuman Laboratories, of Battle Ground, Indiana, have examined artificially dried samples of corn from a pilot wet milling procedure, by a starch yield test using a sectioning technique and for lysine and tryptophan. No single analytical test has been found to predict wet millability as related to drying temperature although the laboratory wet milling procedure yields information of predictive value.



The design of an impact tester to measure the fragility of corn has been completed. The machine consists of an impeller with a five-inch radius of rotation which throws kernels of corn against a steel cylinder that surrounds the impeller.

Studies have shown that harvesting corn at high moisture contents and subsequently drying it with heated air can cause the kernels to become more fragile than the kernels of corn dried with natural air either in the field or after harvesting. In general, corn dried with natural air had breakage of about five percent while corn cured with air heated to 160° F. or more had breakage of about ten percent when subjected to breakage tests at thirteen percent moisture content.

There is a correlation between the number of stress cracks in corn kernels and their fragility. Corn kernels dried at temperatures above 110° F. have a large number of stress cracks and a high degree of breakage while kernels that are dried with unheated air have no stress cracks and a relatively low degree of breakage.

There is a definite relationship between moisture content and the fragility of corn. Field dried corn had ten percent breakage at ten percent moisture content and two percent breakage at fifteen percent moisture content. There appears to be a straight-line relationship between breakage and moisture content within this range. (MQ 3-18)

2. Quality Indicators for Stored Wheat. Under contract with Doty Laboratories, quality tests were performed on stored wheat. Samples of Northern Spring wheat (Selkirk) and Hard Red Winter wheat (Comanche) obtained from the 1960 harvest were placed in storage at 75° F. and at moisture contents of 16, 14, and 12%. Samples were removed and examined for Federal grade, sedimentation, germination, fat acidity, protein content, and moisture, plus analyses conducted on flour from each sample (protein, ash, moisture, maltose, Farinograph, Extensograph, and baking tests). After nine months' storage, the Spring wheat at 16% moisture had declined in germination and sedimentation with corresponding increases in fat acidity values and a decline in baking scores. Fourteen percent moisture samples showed a similar but slower change. Twelve percent moisture samples retained their quality. The Hard Red Winter wheat samples followed essentially the same pattern but at a slower rate. (MQ 3-3)

3. Standardized Lighting Conditions for Grading Grain. At the request of the Grain Division, AMS, work on an acceptable artificial light source for grain inspection was started. In a study of four light sources, an artificial North Sky Daylight was used as standard with conditions of viewing a 45° angle and a 130 foot candles intensity at the viewing surface with a neutral grey surround. It was found that test lamp number 1 (Macbeth TC 440 examolite) would be suitable for inspection purposes. The study was conducted by having 17 individuals who had been screened for color perception compare color chips comprising wheat and corn colors under the standard and under each of the test lamps by a fixed procedure. The ability of these test panelists to correctly match colors under the standard and test light source was the measure of efficiency of the source. Preliminary work on selection of a color background

or inspection indicated that colors complementary to the color of the commodity being examined will be preferable to backgrounds of matching color. (MQ 3-30)

. Fat Acidity. The study of the fatty acid composition of the oil from damaged corn and wheat was completed. This limited study contributed some knowledge to the understanding of the free fatty acid composition of damaged grain. A manuscript on this subject has been accepted for publication. (BS 3-55)

. Sampling Methods. Progress has been made on a plan for cooperative grain sampling research with the grain industry, grain sampler manufacturers, and the grain inspection service. This plan provides for mechanical sampling of boxcar quantities of grain at country loading points and probe sampling of the same loads while enroute to terminal elevators. A tentative procedure for evaluating the performance of various sampling methods and devices has been prepared. (MQ 3-24)

. Moisture Determination in Grain. A study was carried out in which a comparison was made of the results obtained by the more important "basic" methods for moisture determination in seeds. The methods studied were Karl Fischer, near-infrared spectro-photometric, vacuum-phosphorus pentoxide, toluene distillation and air-oven methods. Seeds used included corn, wheat, barley, soybeans, flaxseed, peanuts, seven grasses and eighteen vegetables. The methods were also evaluated on the basis of accuracy, time and skill required.

An investigation was initiated to determine whether or not the amount of inorganic salts present in wheat is a factor accounting for the deviations from oven moisture results which occur when moisture is determined on the Tag or Otopmo moisture meters. There appeared to be some correlation between deviations and inorganic salt content but it was not enough to justify further work.

The near-infrared spectrophotometric method of moisture determination has been applied successfully to the methanol extracts of grain. Attempts to use the method directly on the grain itself, have not been completely successful, but do show promise provided an instrument better suited to the procedure can be built. (MQ 3-23)

. Measurement of Flour Yield of Wheat. Limited tests, using a weighed-weight-volume sample with an air-comparison pycnometer, suggest that density of the wheat may indicate the yield of the flour produced therefrom. (MQ 3-36)

. Quality maintenance in storage.

. Corn. Studies of storage behavior of corn dried to 0, 4, and 8% moisture and in atmospheres of 0, 5, and 20% oxygen at 3 storage temperatures of 1°, 10°, and 50° C. indicate that drying to low moisture levels is feasible but costs and damage inflicted below 2% moisture limits practicality of such low moisture drying. Moisture contents of 2 to 4% appeared to be feasible and resulted in extended storage life with little loss in vigor and viability in these storage studies of two years duration. (MQ 2-34)



Construction of facilities during fiscal year 1962 made possible initiation of studies of microbiological deterioration of corn in storage during the current year at Watseka, Illinois. Examination of some 200 samples from two bins of 1960 crop year blended corn indicated wide variation among the samples in (a) fungus population, (b) germinability, and (c) moisture content.

In a study of corn in two quonset buildings, data indicate that an exhaust system of aeration was not as effective in maintaining quality as was a forced air system. In March 1962, average germination of corn was 63% when aerated by the forced air system vs. 26% when aerated by the fan exhaust system. Striking differences in populations of Aspergillus and Penicillium were evident. A study of grain storage in plastic bags indicated that this storage was unsatisfactory due to failure of the plastic used. (MQ 2-70)

2. Wheat. In a study of the effect of microflora of wheat flour on its stability, biochemical and technological properties, 68 samples of wheat harvested in 1961 representing all climatic and soil regions of Poland were collected and are being examined for surface and interior infestation with bacteria and molds. Vegetative forms of aerobic bacteria were dominant on the exterior of the grain but occasional interior infestation was evident. Eighty-four percent of the samples showed internal infestation with fungi. Sixty-two different bacterial species and 58 fungus species have been isolated. These organisms are being identified with particular emphasis on determining bacterial species which might be injurious if they contaminated wheat flour. The investigation will be continued. (E 21 - AMS - 7 (k))

C. Quality maintenance in transportation. An export study which has been published as MRR 519 entitled, "Maintaining Quality of Pea Beans During Shipment Overseas," contains information on quality maintenance of grain in transportation. In this study, 3 shipping tests were made with Michigan pea beans in 100 pound burlap bags from loading points in the Great Lakes area through the St. Lawrence Seaway to ports in Western Europe. Data on moisture and temperature changes within the holds showed the importance of proper aeration of the hold to prevent moisture increase and mold development in transit. (MQ 2-30)

D. Prevention of insect infestation.

1. Basic Biology and Ecology. Research was initiated at Manhattan, Kansas, in 1962 to study the preconditioning effects of nitrogen and carbon dioxide on the susceptibility of stored-product insects to fumigants. Pure nitrogen appears to be more toxic to confused flour beetle adults than is pure carbon dioxide. This was contrary to what was expected from literature reports. Nitrogen killed 50% of the beetles in 5.5 hours, and carbon dioxide gave the same kill in 7.5 hours. Nitrogen killed 99% of the beetles in 9 hours and carbon dioxide killed 99% in 12 hours. Over 200 respiratory analyses were made of adult flour beetles by means of gas chromatography. These are the first such measurements on record. They provide information on the metabolism of the insects, which gives a criterion other than subsequent fumigant mortality for judging the efficacy of a preconditioning factor. (MQ 1-31)



study has been initiated on the effects on insects of air movements such as occur during the aeration of grain in bins, but there are no results to report as yet. (MQ 1-18)

study was initiated in 1962 to investigate the ecological aspects of varying amounts of foreign material, dockage, and moisture in wheat and corn on the biology of stored-grain insects. Studies thus far have been with the confused flour beetle. Preliminary data show that about the same number of insects were recovered from clean wheat and that with 0.3% dockage. Twice as many were recovered from wheat containing 4.5% dockage, more than 3 times as many from that with 9% dockage, and more than 5 times as many when there was 13.5% dockage. (CCC-1-1-10 (Rev.))

contract with the Hebrew University in Jerusalem, Israel, to determine the individual and combined effects of various environmental factors on the biotic potential of the khapra beetle, is in its early stage, and there is no progress to report. (ALO-AMS-11 (k))

. Insecticide Evaluation. Synergism in repellency was demonstrated for the first time against a stored-grain insect. Test insects exhibited little or no response to wheat treated with either allethrin or piperonyl butoxide. When the two materials were combined the insects were definitely and strongly repelled. Finely divided diatomaceous earths applied to wheat at the rate of 1 to 12 pounds per ton were repellent to test insects. There was a strong correlation between particle size and repellency. The finer dusts with an average particle size of 0.8 microns were more repellent than those with particles of 1.0 to 10.0 microns, especially at lower dosages. Of the candidate repellents received from the Savannah station, the most effective one on wheat was m-dinitro benzene. (MQ 1-2)

series of replicated tests with synergized pyrethrum, premium grade malathion, and a diatomaceous earth applied as protective treatments to wheat, corn, and grain sorghum has been concluded at the end of one year. During that time the grain in small 5-cubic-foot bins was constantly exposed to infestation by several kinds of stored-grain insects. A 57-percent malathion emulsifiable concentrate applied at the rate of 1.5 pints per 1,000 bushels gave excellent protection against infestation to corn and wheat for 12 months but not to grain sorghum. (MQ 1-27)

proportionate share of the insecticide evaluation work of a cross-commodity nature at Savannah, Georgia, has been charged to this area although most of the work is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each commodity area. The entire report is included in Area 13.

. Insecticidal Control. A large scale test in which wheat was treated with several different candidate protectants was concluded at the end of 62 months. Methoxychlor was the only treatment that lasted for the duration of the test and only some of the bins of wheat treated with this material survived. (BS 1-34)

A number of elevator bins of wheat were treated with liquid fumigant using four different application methods. These were: (1) entire dosage on surface of filled bin, (2) dosage divided between half-filled bin and surface, (3) dosage divided between 5,000-bushel layers, and (4) dosage divided between 1,000-bushel layers. Evaluation of effectiveness was based on mortality of test insects, and on gas distribution as determined by chromatographic analysis of air-gas samples drawn from different points in the bins. The number of replications was not great enough to give statistically reliable data but the indications were that the total surface application gave the best results, followed by the other methods in the order just listed. Considerable fumigant mixture component separation occurred at the lower levels of all tanks during the 48-hour gas-sampling period following application of the fumigant. Gas analysis indicated as much as a 20:1 ratio of carbon tetrachloride to carbon disulfide whereas the ratio as applied was 4:1. Component separation did not seem to vary appreciably between methods of application. (BS 1-40)

Laboratory-scale fumigations were set up using 6'x8" circular metal towers as simulated elevator tanks to repeat the preceding comparison of application methods, each method being run 3 times. The effectiveness was in the same rank as had been found in the full-scale elevators. (BS 1-40)

In conducting elevator fumigation tests it was found that low gas concentrations and insect kill occurred in the outer part of the bins, indicating poor lateral dispersion of the fumigant. Elevator employees tended to place the fumigant at one side or the center of the bin. The fumigant should be distributed over the surface of the grain in relation to the underlying volume. For example, in bins of the size used in these tests the part covered by a 6-foot radial periphery represented over 70 percent of the total volume. (BS 1-40)

A series of identical structures for flat storage of grain was fumigated with a mixture of methyl bromide and chloropicrin to compare the effectiveness of gravity penetration, single pass, and closed-recirculation methods of application. The results of these tests clearly demonstrate the superiority of the closed-recirculation method in obtaining uniform distribution of the fumigant and in producing a significantly higher rate of mortality of test insects throughout the grain mass. The closed-recirculation method was also superior for applying a liquid fumigant of the 80:20 carbon tetrachloride-carbon disulfide type, as indicated by higher mortality of test insects throughout the grain mass and by the more uniform distribution of the fumigant. In the gravity penetration fumigation there was not only less uniform distribution but considerable variation in the carbon tetrachloride-carbon disulfide ratios at different locations in the structure. (BS 1-36) (MQ 1-16)

In tests on the effectiveness of phosphine fumigation where there is a temperature differential between the grain in the center and at the periphery of standard circular metal bins, two aluminum phosphide tablets per ton of wheat or shelled corn gave complete kills of introduced test insects in all parts of the bin except near the lower door where gas concentrations were low. Increasing the dosage to 6 tablets per ton, which is the label recommendation, gave complete kill at the doorway. Tests in which an 80:20 fumigant was probed



into so-called "hot spots" at the rate of 5 gallons per 1,000 bushels of shelled corn did not give effective results. There was poor kill of insects in the "hot spot" area and gas analyses indicated the fumigant vapors fell rapidly through the grain to the floor of the bin and then crept to the bin walls. (CCC-1-1-10 (Rev.))

A PL 480 project with the Ministry of Food and Agriculture, Karachi, Pakistan, has just been initiated to study protective treatments against the khapra beetle in grain. There is not yet any progress to report. (A17-AMS-1(k)).

A contract has just been initiated with the Auburn University Agricultural Experiment Station to study insect damage to harvested corn in the Southern states and to assess the value of insect control measures now used for preventing such damage. There is not yet any progress to report. (MQ 1-30(C)).

4. Nonchemical Control. Observations at Watseka, Illinois, are that fewer insects are generally present in shelled corn in aerated standard circular metal bins than in nonaerated bins. The latter require a protective treatment or at least an annual fumigation to keep insects under control. In some cases aerated bins have not required fumigation for 3 or 4 years. The majority of insects found in aerated bins are on or near the floor below the level of the vertical aeration duct. Insect population trends were also observed in two identical aerated flat storage structures containing shelled corn. One aeration system was operating in the normal way, pulling air down through the corn. In the other building the fan was reversed to force air up through the corn. There were very few insects in this corn. Where the normal aeration pattern was followed there were a considerable number of insects present at the corners of the building. (CCC-1-1-10 (Rev.))

A PL 480 project has recently been initiated with the Administration of Agricultural Reserves and Surpluses in Montevideo, Uruguay for a study of the efficacy of underground airtight storage in maintaining the quality of corn and preventing insect infestation during long-term storage. No results are yet available. (S9-AMS-6(a))

5. Toxicology. Under a contract with the University of Georgia, it was found that egg production was not affected by 4 mg. of ethylene dibromide (EDB), equivalent to 40 p.p.m. of the total diet, but was reduced significantly by 8 mg. per day. Production was stopped completely in 7 weeks by 16 mg. per day. Egg weight was more sensitive and as little as 0.5 mg. of EDB per day caused a slight reduction in egg weight. One mg. or more per day caused significant reduction. Ethylene dichloride (EDC) and carbon tetrachloride had no effect on the rate of egg production, either alone or in combination with EDB. Their effect on egg weight however appeared to be slightly additive in combination with EDB. Slightly greater mortality in groups receiving carbon tetrachloride, either alone or in combination with EDB and EDC, suggested the toxic nature of this material at the levels fed. EDB was equally toxic to young pullets and old hens. Autopsy of birds whose rate of egg production was affected by EDB revealed ovaries containing an excessive number of incompletely developed follicles, suggesting an interruption of neurohumoral



control of the growth and shedding of the ova. Microscopic examination of brain, liver, and kidney tissues revealed no histological changes that could be associated with experimental treatments. (MQ 1-8(C))

Results on the effects of ethylene dibromide (EDB) in the diet, on the growth of chicks is included in a manuscript by G. K. Morris and H. L. Fuller, now in press, for early publication in Poultry Science. A reduction in weight gains, feed consumption and feed efficiency occurred when the diet at time of feeding contained 40 p.p.m. or more of EDB. Chemical analysis of the kidney and liver tissues of chicks receiving 280 p.p.m. of EDB in their feed for 2 weeks revealed about 50 p.p.m. of bromides, which is equivalent to 120 p.p.m. of EDB. No additional deleterious effects were observed when ethylene dichloride and carbon tetrachloride at levels of 1280 and 2560 p.p.m. respectively were included in the diet in combination with EDB. (MQ 1-8(C))

A report from the Hebrew University in Rehovot, Israel, shows that in a long-term feeding test started with 1-week-old calves receiving 1 mg. per kilogram of weight of EDB per day in milk, no noticeable change in growth or external appearance occurred during the first 4 weeks of treatment. (A10-AMS-4(a))

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Thompson, J. A., and Sefcovic, M. S. 1961. Defoliation aids dry bean quality. Crops and Soils. August-September Issue, pp. 21-22. (MQ 2-30)

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- Whitney, W. K., Nelson, S. O., and Walkden, H. H. 1961. Effects of high-frequency fields on certain species of stored-grain insects. USDA Marketing Research Report No. 455, 52 pages. (BS 1-33)
- Whitney, W. K., and Walkden, H. H. 1961. Concentrations of methyl bromide lethal to insects in grain. Laboratory studies of sorption rates and effects of concentrations on rice weevil and confused flour beetle. USDA Marketing Research Report No. 511, 25 pages. (BS 1-38)



#### AREA NO. 4a RICE - MARKET QUALITY

Problem. Harvested rice is subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of disease organisms, and by insect infestation during storage either as rough or milled rice. Safe storage of rice for extended periods is a problem of immediate concern to military and civilian defense agencies. To maintain the quality of this product, more precise information is needed on the changes that occur in handling, storage, and transportation. To insure uniform and standardized products in the marketing channels and more equitable prices to all concerned, new and improved methods and techniques for measuring quality factors need to be developed for use in the inspection, grading, and standardization procedures. There is urgent need for more effective methods for preventing insect damage and contamination during storage, handling, processing, and transportation. The need is critical for the development of effective pesticides and application methods that can be used in the marketing channels without leaving objectionable residues. Even more desirable is the development, wherever possible, of effective preventive and control measures utilizing biological, physical, or mechanical means that would completely eliminate the need for pesticidal chemicals.

#### USDA PROGRAM

The Department has a continuing program involving engineers, chemists, and plant pathologists in basic and applied research on the quality evaluation and quality maintenance of rice. This work is located at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station.

A grant with the Department of Plant Chemistry, Valencia, Spain, provides for a study on objective methods for measuring market quality of rice. Its duration is for 4 years, 1960-1964, and involves P. L. 480 funds with a \$19,390 equivalent in Spanish pesetas.

The Department also has a continuing long-term program at Houston, Texas, involving entomologists engaged in applied research on insects attacking rice. The research is conducted in cooperation with various



industry groups, the Agricultural Stabilization and Conservation Service, the Field Crops and Animal Products Branch of the Market Quality Research Division of the Agricultural Marketing Service, and the Texas Agricultural Experiment Station.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists and chemists whose research has cross-commodity application. Although much of the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to stored rice, only a proportionate share of that effort has been allocated to Area 4a.

The Federal scientific effort devoted to research in this area totals 5.7 professional man-years, two of this is devoted to quality evaluation and quality maintenance, and 3.7 to insect control.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations reported grain, rice, feed and seed as a unit, and it is reported under Area 4 Grain.

Industry research on rice is confined to the larger companies that maintain quality control laboratories. Some research on quality evaluation is done together with studies of milling procedures as related to handling and drying. No coordinated program is evident. Estimated annual expenditures are equivalent to approximately 3 to 4 professional man-years.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Quality measurement and evaluation of quality

1. Long Grain Milled Rice. The alkali test for differentiating some long grain milled rice varieties was improved and shortened. A modified procedure has been tested in the field offices of the Grain Division, AMS, and is now being used by rice inspectors. Another procedure was investigated, which employed a rapid sieving technique using the "Carter Dockage Tester."

(MQ 3-12)

2. Degree of Milling. A rice photometer has been developed for objective measurement of degree of milling. After an initial study of specially prepared samples, the prototype meter was employed in study of the large number of samples at the Rice

Inspection Office, Grain Division, New Orleans, Louisiana. Simple correlation between the meter reading and visual grades of milling was  $r = .902$ , indicating excellent response even when general appearance, percent broken, and variety were ignored. Use of a correction factor for variety yielded a multiple correlation coefficient of .920 which suggests the value of such a correction factor. Preliminary data indicate that the photometer can be used to measure the degree of parboiling of rice.

(MQ 3-16)

3. Chemical Indicators of Quality. Under a P. L. 480 grant, a study has been initiated for the development of chemical indicators of rice quality. Various constituents of ten rice varieties are being examined organoleptically for preference and cohesiveness. In the varieties studied, water absorption and the blue test were not useful quality measurements but viscosity of rice pastes showed some relationship with quality. Starches isolated from each variety were characterized by potentiometric titration with iodine, spectrophotometric measurement of the starch-iodine complex and by determination of the limiting viscosity. Only the latter appeared promising as an index of quality; the same was true with isolated amylose  $A_1$  and amylose  $A_2$ ; ageing of rice improved its quality with concomitant change in physico-chemical properties. Another important observation was that there is a close relation between nitrogen content of the outer layer of the kernel and the cohesiveness of the cooked rice grains.

(E25-AMS-1(a))

#### B. Quality maintenance in handling and packaging

Study was made of the maturity of Bluebonnet 50 rough rice at harvest and three drying methods as measured by the yield of head rice. Maximum yields of head rice were obtained from samples harvested at 28.6% moisture content using infrared drying procedures. Head yields of rice harvested at 21% or lower moisture content were not significantly affected by drying methods. Infrared drying techniques were investigated to determine their effectiveness in controlling fungi infesting rough rice. Treatments which resulted in maximum head rice yields also reduced internal infestation 94 to 100%. Preliminary studies of fungistatic chemicals to prevent re-infestation of infrared-irradiated rough rice were initiated. To date, 5,6-dichlorobenzoxazolinane-2 appears to show promise.

(MQ 2-7)

### C. Quality maintenance in storage

Mold development in rough rice, Bluebonnet 50, was studied in small bins aerated at air-flow rates of 0.2 to 9.5 cfm per barrel. Virtually 100% of the rice had been invaded by field molds prior to initiation of this study. Storage molds increased and field molds decreased during the storage period. The Aspergillus flavus-oryzae group was predominate. At the minimum aeration rate of 0.2 cfm per barrel, the storage mold prevalence increased to 88% in 16 days, while bins at the highest rate of aeration showed maxima of about 17% in 19 days.

Relation between endosperm discoloration ("damaged" and "heat damaged" kernels) and fungi infesting rough rice was studied. Filtrates from all fungi tested to date stained milled rice, but varied in the degree and type of discoloration caused. Inoculation of sterile rough rice with selected fungus isolates resulted in significant increase in discolored kernels if incubated in a humid atmosphere.

Loss of dry weight of stored rough rice and reduction of milling yields were demonstrated to occur as a result of fungus infestation. For example, after 7 days' storage in a saturated atmosphere, samples inoculated with Penicillium puberulum lost 9.6% dry weight and head rice yield was reduced 18.2%.

(MQ 2-7)

### D. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory tests at Houston, Texas, indicate that Bayer 29493 may warrant further investigation as a protectant for rough rice. In small-scale tests it has given protection equal to malathion for 1 year.

(MQ 1-15)

A small part of the program on insecticide evaluation at Savannah, Georgia, has been indicated as pertaining to rice although much of the research at Savannah is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore, the entire report is included in Area 13 "Insect Control in Marketing Channels - Cross Commodity."



2. Insecticidal Control. Field tests in 1961 indicated that phosphine gas is an effective fumigant for insect control in bulk rough rice in vertical bins. Chemical analyses of fumigated rough rice indicated no significant residue of phosphine gas. Laboratory studies showed no significant reduction in germination of rice exposed to phosphine. Further testing in 1962 established a tentative effective dosage level of phosphine for effective fumigation of bulk rough rice in vertical wooden storage bins. Field testing also established the tentative dosage levels of two liquid fumigants for effective insect control in bagged rough rice under plastic film covering the stacked bags.

(BS 1-30)

Phosphine gas was found to be an effective fumigant for bagged milled rice under plastic film and a tentative dosage level was established for fumigation at 80° F. or above. The minimum effective dosages were tentatively established for two liquid fumigants for insect control in bulk milled rice in vertical storage bins.

(MQ 1-3)

Malathion applied as a bulk treatment to rough rice as it goes into storage has been found effective in preventing insect infestation for up to 1 year. This protective treatment has been widely accepted by the rice industry.

(MQ 1-19)

3. Insecticide Residue Analysis. This work at Savannah, Georgia, is reported under Area 13, as in the case with the insecticide evaluation work.

4. Nonchemical Control. Laboratory tests indicated that certain inert dusts may be suitable as protectants for bulk rough rice. Some that appeared to warrant further investigation included Santocel C, Dri-Die 68, and Cab-O-Sil M5. A limited field test of these dusts was conducted for a short storage period. Results indicated positive prevention of insect infestation. On the basis of these preliminary results, one rice milling firm plans some limited application to 1962 crop-year rice.

(MQ 1-15)

In the exploration of nonchemical methods for controlling insects so that pesticidal residues can be minimized, attention has been given to the effect of an infrared rice drier on the mortality of stored-rice insects. Special consideration has been given to the

three species of insects whose larvae develop inside the rice kernels and may therefore be more difficult to kill with such a treatment. Laboratory testing showed that infrared irradiation at intensities and exposures known to be harmless to the rice can be lethal to the internal immature insects. Differential mortalities occur according to the species or age of the insect, rate of heating, and final temperature reached.

(MQ 1-9)

5. Insect-resistant Packaging. These studies at Savannah, Georgia, as with those on insecticide evaluation and insecticide residue analysis, are reported under Area 13.

PUBLICATIONS REPORTING RESULTS OF USDA AND  
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Objective Measurement and Evaluation of Quality

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## AREA NO. 4b FORAGE, FEED AND SEED -- MARKET QUALITY

Problem. Forage, feed, and seed may suffer damage or deterioration in quality from insect attacks, from microorganisms, and from normal metabolic changes. Insect infestations are a major problem with feed and do much damage both to the individual components and to the mixed product. Seeds are also subject to insect damage. Other major problems with seed involve methods of determining seed quality, blending and selection of seed samples, improved storage conditions to prolong viability, seed and seedling classification, and protection of seedlings from disease organisms.

### USDA PROGRAM

The Department has a continuing long-term program involving chemists, seed technologists and plant pathologists engaged in both basic and applied research on quality evaluation and quality maintenance of feed and seed. This research is conducted at Beltsville, Maryland, and at College Station, Texas, and also by research contract with experiment stations of Mississippi, Iowa, and Oregon.

A grant with Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, and involves P.L. 480 funds with a \$103,785 equivalent in Israeli pounds.

A P.L. 480 grant with Instituto Biologico, Sao Paulo, Brazil, provides for a study of substrate moisture levels for germination testing of agricultural seeds. Its duration is 5 years, 1962-1967, and involves \$31,016 equivalent in Brazilian cruzeiro.

The Federal scientific effort devoted to research in this area totals 4.5 professional man-years, of which 1.3 man-years are by research contract.

A research study on storage conditions for keeping certain grass seeds has been completed.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 16.2 man-years divided among subheadings as follows: Objective measurement and

evaluation of quality 9.6, quality maintenance in handling and packaging .8, post-harvest physiology 5.8. The work includes Regional Projects NEM-22, Purity of Seeds; NCM-23, Facilitating Seed Marketing; SM-21, Seed Marketing; and WM-35, Seed Marketing. Several aspects of objective measurement and evaluation of numerous types of seed for quality are subjects of research. This research includes techniques to evaluate seed damage; germination and means of reducing germination time; the interrelations of laboratory germination, planting rate and environmental conditions upon stand; interaction of light, thermal and substrate factors in seed germination; means for evaluating seed vigor; determination of varietal purity; effects of temperature and humidities on longevity of seed; methods of refining trueness-to-type; physiological requirements and changes in storage; and laboratory techniques that will provide an indication of field performance.

Research on post-harvest physiology of seeds and related subjects deals with moisture content, variety and maturity, effects of microorganisms on germination of seed, identification of mold types, testing fungicides for mold control, studies on respiratory changes, and respiratory enzymes.

Industry, principally large feed companies, do some research on blending of feed ingredients--particularly microingredients--and in sampling procedures, and several large seed companies maintain seed germination laboratories which do research on seed germination and vigor. Work on seed storage and packaging is also under way. The American Seed Trade Association has established a research institute which is supporting work on seed quality measurements. Estimated annual expenditures are equivalent to approximately 10 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement and evaluation

1. Seedling Classification Studies. Study of seedling classification relating to laboratory germination tests resulted in a new recommended procedure for browntop millet seeds, involving a period of predrying at 35° C. and use of  $\text{KNO}_3$  and thiourea, with germination at 5° dark 35° light for 21 days. Use of gibberellic acid seemed to show no advantage over the above procedure and the fungicides phenacridane chloride and Ceresan gave control but again showed no advantage over the above treatment by their use. Studies of the

problems of seedling classification of cotton indicated that this is primarily a disease problem with Diplodia, Aspergillus, Fusarium, and Rhizopus involved in the damage to cotton seedlings. The laboratory participated in extensive tests on seedborne diseases by procedures defined by an international referee committee.

(MQ 3-19)

2. Physical Techniques for Seed Quality. A procedure for staining light-colored legume seeds to determine seed coat damage has been developed which involves the use of indoxyl acetate in a simple dyeing procedure. It could be made applicable to seed inspection procedures.

(MQ 3-18)

Study of use of an X-ray method for determining pure seed was found to be impractical for use with seeds as small as Bahia grass, but the system could be readily used to determine purity of larger seeds such as those of pine. Preliminary work indicates the feasibility of a vacuum impregnation of seed with heavy metal salt solutions as a procedure for purity determination. Differences in density permit separation of components.

(BS 3-59)

3. Seed Metabolism. Study of the amino acid metabolism of germinating peanuts resulted in the finding of a new enzymatic reaction, the aldol cleavage of gamma hydroxy gamma -methyl- $\alpha$  -ketoglutarate. The reaction is apparently related to the metabolism of gamma methylene glutamic acid which is formed in large amounts during early phases of germination and is subsequently transported to the leaves and stems of the growing plant. Study of seed nucleic acids and their relation to germination is under way. Procedures have been developed for (a) determination of RNA and DNA in peanut axis and cotyledon (b) isolation of RNA and DNA from peanut cotyledons and for separation of these two components. With these procedures it has been determined that there is a net synthesis of both RNA and DNA during germination.

(MQ 3-32)

4. Seed Blending. Seed blending methods for commercial seed lots are being investigated under contract arrangement with Mississippi State College. Both batch and continuous blending procedures, using proportional feeders have given acceptable results with lots of seeds which are relatively uniform in size and mass. Satisfactory blends of seeds differing in size, shape and texture have not



been obtained by use of existing equipment. Studies of devices which fill containers with proportional amounts of each seed type are under study and appear at this time to be the most feasible system of handling such lots.

(MQ 3-8(C))

5. Mechanization of Purity Analysis. A contract with Oregon State University on the development of a system for mechanizing purity analysis of seed crops has begun. A microscopic inspection station has been developed and modifications of the vertical vibrator feeder has been accomplished. Work has been done on the sub-sampling device, on a vibrator separator and on a new velvet roll cover. A survey of weed and crop contaminants found in various seed crops has been completed.

(MQ 3-21(C))

#### B. Quality maintenance in storage

1. Seeds. A contract study at Iowa State University in which Kentucky bluegrass, creeping red fescue, cabbage, and onion seed were stored in several packaging materials at five temperature-relative humidity combinations has been completed. Moisture content was found to be the most important factor affecting viability. Seeds were stored successfully for 2 years at room temperature, if their moisture content was at or below 7%. Metal cans were the only completely satisfactory container for maintaining seed viability. The effect of temperature on viability was intimately related to moisture content. An intensive literature survey of storage is under way. Data are being arranged by a card file system and a series of charts are being developed to summarize existing storage information.

(BS 2-144(C))

With the availability of new seed laboratory facilities, work on microbiological deterioration of grass seeds has begun. A literature survey has been completed.

(MQ 2-62)

2. Cereal Grains and Feeds. Under a P.L. 480 grant with the Israel Institute of Technology, a study has been initiated of the effect of storage on the protein nutritive value of cereal grains and feeds. Soybean, peanut and cottonseed meals, and rice and wheat have been placed in storage under different conditions of temperature and humidity. The samples will be analyzed periodically by a large number of test methods in order to find a reliable quick indicator of change in nutritive value as reflected in simultaneous animal assays.

(A10-AMS-7)

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COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

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## AREA NO. 5 LIVESTOCK AND MEAT -- MARKET QUALITY

Problem. Meat is a very perishable commodity which varies greatly in quality characteristics such as tenderness, juiciness, flavor, and fat content. To insure more uniform grades and standardized products, better objective tests for measuring the quality attributes of meat are needed. Also needed are more effective methods to minimize shrinkage while maintaining optimum quality, bloom, and shelf-life of the product as it moves through market channels.

### USDA PROGRAM

This work is being conducted at Beltsville, Maryland, with the cooperation of the Animal Husbandry Research Division, ARS, and also in part by research contract with the Universities of Wisconsin and Oklahoma. Research, basic and applied, includes the development of objective methods for evaluating the composition of livestock, carcasses, and meat cuts; the application of ultrasonic techniques to estimate the thickness of backfat and muscling in live hogs, cattle, and sheep, and the use of measurements of the low-level natural gamma-ray emission of meat cuts for estimating their lean content. New techniques for measuring meat tenderness are being developed and evaluated.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years of which 2.4 man-years is by research contract. The total effort is devoted to objective measurement and evaluation of quality. During the report period, work on criteria for identifying meat-type hogs and feeder pigs (BS 3-74) was completed. Studies on gamma-ray measurements of meat cuts (BS 3-5) were also completed.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 8.1 professional man-years divided among subheadings as follows: Objective measurement and evaluation of quality 6.7, quality maintenance in handling, packaging and storage 1.4. The former includes objective measurement of meat quality on beef, lamb, and pork, including physical and chemical changes in fat and protein; changes in color of different cuts of meat; organoleptic evaluation of tenderness;



histological structure; collagen content; and amino acids; influence of pre-slaughter treatment; effects of marbling, fat covering, color maturity, and other carcass characteristics on the basis palatability components. Under handling, packaging, and storage the work concerns maintenance of product color, control of moisture, prevention of off-odor adsorption, and of microbiological spoilage.

Industry and other organizations also conducted research in this area. The American Meat Institute Foundation research program includes various aspects of meat processing, prepared meats, and meat cookery, and amounts to an estimated annual expenditure equivalent to approximately 3 professional man-years. Many meat packing companies have their own laboratories. However, to a large extent, the work of these laboratories is slanted toward the development of new processing procedures, products, and formulations, thus limiting the research effort on evaluation of market quality and quality maintenance. Much of the research of company laboratories in this area is kept confidential. Estimated annual expenditures are equivalent to approximately 8 professional man-years.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement and evaluation of quality

1. Evaluation of Live Animals in Relation to Composition. Analysis of much of the data from extensive research on the relationship of ultrasonic readings of backfat and muscle thickness of live swine has been completed. Highly significant multiple correlations were found between three or more successive live animal ultrasonic readings of backfat thickness and total separable fat. A highly significant multiple correlation was found between five successive live animal ultrasonic readings of backfat thickness and total lean content.

Research on the use of nondestructive measurements of natural potassium - 40 gamma radiation revealed that natural radioactivity was highly correlated with the percent of separable lean and separable fat of pork hams and beef rounds.

(BS 3-5)

2. Measurement of Tenderness. A new device for evaluating the tenderness of sliced meat has been developed. This Slice-Tenderness Evaluator (STE) was used in conjunction with a standard

commercial testing instrument, in cooperative tests with ARS, to evaluate pork roast slices. The evaluation with the STE were in good agreement with a subjective taste-panel evaluation and a standard objective method which involves the use of meat cores (Warner-Bratzler shear).

(MQ 3-34)

3. Factors Influencing Quality in Pork. A total of 466 carcasses were selected for this study and included animals of known and unknown histories. Marbling in the longissimus dorsi and chronological age were found to be the most important factors associated with palatability. Fresh pork loins were generally acceptable in palatability if they contained approximately 20% of intramuscular fat on the moisture free basis and were from animals less than 220 days of age. The palatability of commercially cured hams was acceptable regardless of chronological age, carcass weight or intramuscular fat content. Bacon became more tender with increasing amounts of intramuscular fat. Flavor and juiciness of bacon were not affected by differences in chronological age, carcass weight, or intramuscular fat. Loin eye area per hundred pounds of carcass weight was of greater value in the prediction equation of lean yield than was unadjusted area of the longissimus dorsi. The gilt carcasses exhibited higher lean cut yields, larger loin eye areas, higher percentages of loin and ham, less backfat thickness and were longer than barrow carcasses.

(MQ 3-9(C))

4. Influence of Bovine Age Upon Meat Characteristics and Grade. The contractor has been evaluating the work of the past 3 years and making statistical analysis of the data. Several publications have already been prepared and several more will be ready in the next few months. Some of the important findings to date are the following: It was found that tenderness of the longissimus dorsi steaks as measured by the Warner-Bratzler Shear and panel (with marbling of each carcass at or closely approaching either the "slight amount" or "slightly abundant" level) decreased significantly with increasing animal age. The greatest difference in tenderness was observed between the 18 and 42 month age groups. The effect of aging the meat 14 days varied with animal age, marbling level, and the tenderness measure used. Moisture, ash, and protein contents of loins were not significantly different for the age groups except that the 6-month old calves had slightly higher moisture values.

(MQ 3-10(C))

5. Criteria for Identifying Meat-Type Hogs and Feeder Pigs. The use of the live animal probing technique was demonstrated in purebred herds of swine as a means of assisting breeders in locating and identifying meat animals and strains. In addition, live-hog measurements of 107 crossbred barrows and gilts at 75, 125, and 225 pounds were studied to determine the relative accuracy of backfat probes, scores for market grades, and various body measurements for estimating carcass value. Backfat thickness generally was the most important measure for predicting individual differences in yield of fat cuts, yield of lean cuts, yield of lean meat in ham, and loin-eye area. However, with 75 and 125 pound gilts, score for market grade was slightly more accurate for predicting yield of lean cuts and yield of lean meat in ham than was backfat thickness. The results suggest that of the 12 live-hog measurements used, for 225 pounds swine and lighter weights, backfat thickness was the best single measurement for estimating meatiness in hogs, followed successively by depth of middle, width of middle, width over ham, and score for market grade.

(BS 3-74)



PUBLICATIONS REPORTING RESULTS OF USDA AND  
COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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## AREA NO. 6 OILSEEDS AND PEANUTS -- MARKET QUALITY

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus damage and contamination, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various species of insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization procedures.

### USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of peanuts and soybeans. Research on soybeans is conducted at Washington, D. C.; research on peanuts is done at Raleigh, North Carolina, in cooperation with the North Carolina State College and Federal-State Inspection Service and also by research contract with Texas A & M.

A P.L. 480 grant with the College of Agriculture, Olsztyn, Poland, provides for a study of storage changes in flaxseed. Its duration is 4 years, 1960-1964, and involves P.L. 480 funds with an \$18,127 equivalent in Polish zlotys.

The Department also has a continuing long-term program at Tifton, Georgia, involving entomologists engaged in applied research on problems of insect infestation, damage, and contamination of peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service of this Department, growers cooperative associations, and various industry groups.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists and chemists whose research has

cross-commodity application. The entire program is discussed in Area 13. Much of the work on insecticide evaluation and insecticide residue analysis has a direct or indirect relation to peanuts and peanut products. In addition, a portion of the programs on insecticide evaluation and residue analysis have been designated specifically for research on peanut-insect problems.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 3.5 is devoted to quality evaluation and quality maintenance, and 2.8 to prevention of insect infestation.

A project on the field evaluation of equipment for rapid measurement of oil and moisture content of soybeans was completed.

A research project was completed covering an evaluation of improved equipment and methods for the rapid determination of oil and moisture in soybeans.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 1.2 professional man-years engaged in quality maintenance during storage, and includes: Chemical, biochemical, and physical properties; changes in odor, color, flavor, and nutritive factors affecting the market value of peanuts. The research also includes the relation of microflora to respiration and associated deteriorative changes.

Industry and other organizations also conduct research on oilseeds and peanuts to develop methods for measuring quality factors in edible oils for the purpose of improving their quality control systems, and several peanut processors have cooperated in the malathion testing program by roasting treated peanuts or by making peanut butter, then conducting taste and odor evaluation panel tests to determine whether the treatment had any adverse effect on quality. The estimated annual expenditures are equivalent to approximately 6 professional man-years.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. Peanut sizers, shellers and splitters developed by this project were used



for all official inspection of farmers' stock peanuts in the United States during the 1961 marketing season. Research work on this project has been directed toward further development of the pneumatic peanut sampler, development of a sample divider for peanuts, design of a cleaner for small samples of farmers' stock peanuts and determination of the effects of various curing treatments on peanut quality. The pneumatic peanut sampler has been approved for use in the official grading of farmers' stock peanuts. The Southeastern Peanut Association has requested that use of either the pneumatic or the spout-type peanut sampler be made mandatory for all official grading of farmers' stock peanuts in the southeastern growing area after the 1962 marketing season. Final development of the pneumatic sampler was completed through a contract agreement with the Georgia Tech Research Institute for the design and testing of the mechanical and structural components of the machine. The Federal-State Inspection Service and the Southeastern Peanut Association also cooperated in the final development, and paid the costs of constructing and testing a prototype model of the sampler. The Fruit and Vegetable Division of the Agricultural Marketing Service cooperated in testing the sampler for accuracy.

A sample divider to draw subsamples from large samples has been developed. The divider is designed to draw a subsample 1/8th the size of the sample in one pass through the divider. The divider was tested in cooperation with the Fruit and Vegetable Division of the Agricultural Marketing Service and was found to draw a representative subsample from samples containing a mixture of sand, hay, rocks, shelled kernels, and peanuts. The divider is to be used on all of the pneumatic peanut samplers to draw a subsample for grading purposes. Further testing is necessary to determine the suitability of the sample divider for use in grading work on other commodities.

A small sample cleaner for farmers' stock peanuts has been designed as the result of a request from the Federal-State Inspection Service and the Southeastern Peanut Association. The cleaner is designed to enable one inspector to determine the percent of foreign material and shelled kernels in a 1000-gram grading sample of farmers' stock peanuts in approximately three minutes. An experimental model of the cleaner has been constructed and will be tested by the Federal-State Inspection Service during the 1962 marketing season.

(MQ 3-29)

2. Evaluation of Damage Factors. Studies to determine the effects of curing treatment on the quality of Virginia-type peanuts have produced the following results: Previous findings were verified that drying rate, independent of temperature, causes peanut kernels to split and skin during the shelling operation while off-flavor is caused by curing temperatures over 95° F. Tests indicated that the hardness of peanut kernels is not appreciably affected either by rate of drying or by curing temperatures. The size of peanut kernels decreases with a decrease in moisture content.

(MQ 3-26)

Studies have been made in Texas to determine the effects of date of harvest and curing treatment on various chemical and organoleptic properties of peanuts. Spanish-type peanuts of the Spantex variety were used in the tests. Preliminary findings from studies on chemical composition follow: (1) Kernel size is better correlated with observed changes in chemical constituents than date of harvest. It appears that kernel size is related to maturity within a given harvest of peanuts, although it is recognized that other factors, such as growing conditions, may affect the size distribution of peanut kernels also. (2) The total pigment level in peanut oil decreases with an increase in kernel size and increases with curing temperature. (3) Peroxide values for extracted oil do not appear to be correlated with kernel size. (4) Crude lipid content increases with kernel size. (5) Total sugar content decreases with an increase in kernel size. (6) Crude protein increases with an increase in kernel size. (7) There does not appear to be any correlation between oleic, linoleic or palmitic acid content and kernel size.

Organoleptic tests which have been completed indicate that size, time of field curing (ripening) and curing temperature affect the flavor of peanuts.

(MQ 3-26)

3. Improved Equipment and Methods for Rapid Measurement of Oil Content of Soybeans. Field testing of the rapid oil testing method and equipment was continued an additional year at Mankato, Minnesota, to provide additional data. A report is in preparation covering 3 years' field testing at Mankato, Minnesota, 2 years at Clarksdale, Mississippi, and 1 year at Decatur, Illinois. Findings indicate that the new method is much more rapid and is as accurate as the standard laboratory method.

(MQ 3-2)



## B. Quality maintenance in storage

1. Flaxseed Storage. Under a P.L. 480 grant a study has been initiated of the influence of storage changes in flaxseed on quality of seed and properties of linseed oil. During the first 2 years from 11 to 15 varieties of oil- and fiber-types of flax were studied. Chemical data were obtained on flaxseed grown in various areas; qualitative and quantitative changes during ripening; technological value as related to climate; influence of storage conditions on quality; and effect of temperature and humidity on quality. Preliminary results revealed lipolytic activity of lipases with optimum activity of pH 5 and 8.0 at 37° C. which indicate the presence of two kinds of enzymes. These data and results obtained in subsequent years will be statistically analyzed.  
(E21-AMS-6(k))

2. Soybean Oil Storage. Observations at the end of the 3-year period indicate different rates of change in characteristics of soybean oil in storage than in cottonseed oils. Although the once refined soybean oils decrease in color with a linear relationship to time and temperature, the rate of decrease is not dependent on the initial color as was the case of the refined cottonseed oils. Whereas crude cottonseed oils all increased in refined color during the entire storage period (except in the instance of the filtration extracted oil), all of the crude soybean oils decreased in refined color during the first 2 years, but at the end of 3 years there is little further decrease. The crude degummed soybean oils are also following this trend. All of the soybean oils are showing insignificant changes in bleached color and free fatty acids.

The peroxide values of the once refined soybean oils increase at about the same rate as the refined cottonseed oils. The relationship with time-temperature is also linear. Crude soybean oils showed some increase in peroxide value initially and at the end of 3 years showed rapid increase in contrast with crude cottonseed oils which changed little in peroxide value over the entire storage period. The degummed crude soybean oils are following a trend more closely to that of the refined oils.

The data on "dimer" changes and panel evaluations of flavor of soybean oils at the end of 2 years of storage do not definitely indicate any trends or relationships to peroxide value increases during storage.

(MQ 2-44)



## C. Prevention of insect infestation

1. Insecticide Evaluation. Beginning in FY 1963 additional research was initiated at Savannah, Georgia, on insecticide evaluation specifically related to the peanut-insect problem. The work is just beginning and there is no progress to report. Other insecticide evaluation work of a cross-commodity nature also has direct or indirect relation to peanuts. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

2. Insecticidal Control. In 1961 large-scale tests on the protection of peanuts against insect infestation were continued in commercial warehouses. Data collected in these studies showed that malathion, properly applied to farmers' stock peanuts as a bulk treatment at load-in, supplemented by periodic surface treatments during storage, effectively controlled insects during the normal storage period. The malathion bulk-plus-surface treatments were more effective, as well as more economical, than synergized pyrethrum applied either as surface or bulk-plus-surface treatments. Chemical residue data obtained during these studies showed that the bulk-plus-surface malathion treatment could be applied to the farmers' stock peanuts without excessive residues resulting on the shelled peanuts. Data obtained from these studies were used by the Food and Drug Administration as a basis for changing the residue tolerance from 8 parts of malathion per million on the whole peanuts to that amount on the kernels only, with shells discarded. It was further demonstrated that the malathion disappeared rapidly during the first month and at a more gradual rate during the remainder of storage.

(MQ 1-14)

Data collected in 1962 from samples of farmers' stock peanuts stored in commercial warehouses confirmed that malathion, properly applied to peanuts by warehousemen at time of load-in and supplemented by periodic surface treatments during storage, effectively controlled insects during the normal storage period. Chemical residue data obtained during this study provided further evidence that residues on shelled peanuts were at a very low level and well within the established tolerances. Peanut oil samples, collected from oil mills processing treated peanuts, have shown that some malathion residues occur in crude oil but only a trace or none in the finished or deodorized refined oil. Peanut butter made from treated peanuts had only a trace or no malathion present. There were no off odors

or flavors reported by the industry as a result of the treatment. It is believed that nearly every warehouseman in the Southeast storing bulk farmers' stock peanuts, whether for himself or under government contract, followed the USDA recommendations for the application of a bulk treatment at the time of load-in. The majority of them used malathion. Insect damage was held to an extremely low level, resulting in extensive savings and a cleaner product for processors and consumers.

(MQ 1-14)

3. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

PUBLICATIONS REPORTING RESULTS OF USDA AND  
COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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Quality Maintenance in Storage

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Prevention of Insect Infestation

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## AREA NO. 7 COTTON AND COTTONSEED -- MARKET QUALITY

Problem. Cotton: Technological advancement in production, harvesting, and ginning of cotton brought on by mechanization has resulted in changes in the quality of cotton fiber which are not recognized by present methods of quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cottons which have been subjected to various production, harvesting, and ginning practices in preparation for markets. New and improved techniques, devices, and procedures for measuring quality factors of cotton fiber are needed to provide better grading and standardization of lint cotton, and indicate the true processing performance and manufactured product quality.

Cottonseed: Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes, and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading and standardization programs.

### USDA PROGRAM

The Department has a continuing program involving textile engineers, cotton technologists, physicists, chemists, and engineers in basic and applied research on objective measurement and evaluation of quality of cotton fiber and on the quality evaluation and quality maintenance of cottonseed. The research is conducted at Washington, D. C., College Station, Texas, Clemson, South Carolina, in cooperation with Clemson College and by research contract with Clemson College, Texas Technological College, Auburn University, and North Carolina State College.

The program includes the following foreign projects under P.L. 480: A grant to Centre de Recherches des Industries, Rouen, France,

provides for an investigation of fiber maturity and breakage during mechanical processing of cotton, and the relation of these factors to processing performance and product quality. Its duration is 4 years, 1961-1965, and involves P.L. 480 funds of \$64,500 equivalent in French francs.

Another grant to the same institution provides for development of an instrument for homogenizing and orienting fibers in samples for cotton testing. Its duration is 4 years, 1961-1965, and involves P.L. 480 funds with a \$47,000 equivalent in French francs.

A grant with Fiber Research Institute, T.N.O., Delft, Holland, provides for a study of the influence of length properties on the mill processing performance of cotton. Its duration is 3 years, 1962-1965, and involves P.L. 480 funds with a \$58,000 equivalent in Dutch guilders.

The Federal scientific effort devoted to research in this area totals 20.2 professional man-years subdivided as follows: Cotton 17.7, with 4.7 under research contract; and cottonseed 2.5.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 0.7 professional man-years on a program of quality evaluation of new cotton varieties. Factors such as fiber strength, length of fiber, processing properties, wearability, and wash-and-wear properties are being investigated.

Industry research in this area is concerned with quality evaluations of fiber and processing performance. However, a large portion of it is for internal use and is kept confidential. Estimated annual expenditures are equivalent to approximately 10 professional man-years.

A study to evaluate the relationship of cotton fiber properties to processing performance has been completed (BS 3-29).

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurements and evaluation of quality of cotton

1. Effect of Various Production, Harvesting and Ginning Practices on Spinning Performance and Cotton Quality. Several cooperative studies were undertaken to determine the effects on cotton fiber

properties and processing performance of a number of practices of interest to research workers in both the Department and various segments of the Cotton Industry. These studies, cooperative with other Divisions, are being conducted by the AMS Cotton Quality Research Station, Clemson, South Carolina. The progress made on these studies are as follows:

(a) Multiple Lint Cleaning. This study involved early and late season cottons, mechanically harvested, and represented three areas of growth (California, Texas high plains, and Mississippi Delta). Two gins were used in each area and the cottons were ginned with 4 levels of lint cleaning (no lint cleaning, 1 lint cleaning, 2 lint cleaning, and 3 lint cleaning). Seed cotton cleaning and drying were not variables. The results obtained from this study indicated the following:

(1) The grade index progressively increased as lint cleaners were increased from zero to two lint cleaners. The addition of the third lint cleaner did not cause any appreciable increase in grade.

(2) Classer's staple length showed only a slight increase when one lint cleaner was used. The addition of a second lint cleaner had no effect on classer staple while the addition of the third lint cleaner caused a reduction in staple length.

(3) Lint cleaners caused a reduction in non-lint content as would be expected. The greatest reduction was noted from the use of one lint cleaner. The contribution of the third lint cleaner was negligible.

(4) The length uniformity, percent short fiber, and neps in card web were affected in similar manner by the use of additional lint cleaners. That is, as lint cleaners increased, the greater the adverse effects on the above properties.

(5) Yarn appearance was not affected by the use of one lint cleaner. However, as additional lint cleaners were added, a slight reduction in yarn appearance grades resulted.



(6) The breakfactor increased slightly with the use of one lint cleaner. However, a reduction in the breakfactor resulted as additional lint cleaners were used.

(7) The effects of lint cleaning on the spinning performance of these cottons were somewhat different for the early and late seasons. For the early season cottons, the ends-down per 1000 spindle hour increased rapidly as the number of lint cleaners increased. For the late season cottons, the results indicate that one lint cleaner is beneficial to spinning performance whereas, additional lint cleaners seem to decrease spinning performance by increasing ends-down per 1000 spindle hour.

(b) Smooth Leaf Vs Hairy Leaf Varieties. There are indications that the Smooth Leaf varieties of cotton produce higher grade lint than the more common "Hairy Leaf" varieties, when ginned under similar conditions. This study was designed to determine the cleaning capabilities and processing performance of these two varieties of cotton under certain ginning conditions and the effects of these ginning conditions on fiber properties and spinning performance. This study has not yet been completed.

(c) Mechanical Picker Spindles. This test was designed to study the effects of three types of mechanical picker spindles used in mechanically harvesting of cotton on fiber properties and spinning performances as compared to hand harvested cottons. There has been some indications, on previous studies, that cottons harvested by hand spin much better than mechanically harvested cottons when ginned under similar conditions. The processing of this study is now complete and the data are being analyzed for preparation of a manuscript.

(d) Moisture Control - Ginning-Spinning Study. Two studies involving various methods of fiber moisture control during ginning have been completed in the ginning phase of these studies. One of the studies was designed to study the effects of drying the seed cotton at various temperatures, using time of exposure to produce certain levels of lint moisture at the time of ginning. These factors are being evaluated as to their effect on fiber properties and spinning performance. The second study was designed to dry the lint on seed cotton to various moisture levels, down to 2 percent, for seed cotton cleaning

operation and then restore moisture to the seed cotton before the ginning process by exposure to water vapor or spray. The mill processing of these studies have been completed and an analysis is being made to determine the effects of these various practices on fiber properties and spinning performance.

(e) Defoliation Study. This study was designed to determine the effect of 3 levels of defoliation (premature, normal, none), 2 levels of gin drying and 3 levels of gin cleaning practices on fiber properties, spinning and weaving performance. The cotton involved was of a long staple variety, mechanically harvested, and was processed into combed yarns. The spinning operation has been completed and the weaving phase is now underway and is expected to be completed early next year.

II. Development of Instrument for Fiber Length Measurement. Research was continued in the development and testing of the electrical resistance method for measuring length and length distribution of cotton fibers. The measuring device has been redesigned and a new portable unit built. The new unit is much simpler in construction and operation than the original laboratory model. The analog computer has been redesigned and rewired to solve 5 empirical equations for predicting length factors (mean length (array), upper quartile length, percent fibers by weight shorter than  $\frac{1}{2}$  inch, percent fibers by weight between  $\frac{1}{2}$  and 1 inch long, and percent fibers by weight longer than 1 inch) from the length frequency data obtained from the clamped cotton sample by the resistance device. This length information, along with the length-frequency data, is printed on paper tape for permanent record.

The complete unit (measuring instrument, computer and recorder) is portable, requiring only a source of 120 volts a.c. and a climate conditioned room similar to those used at present for testing cotton fibers.

(MQ 3-4)

III. Evaluation of Relationships of Cotton Fiber Properties to Product Quality. Multiple correlation values denoting the degree of average relationship between fiber measures and yarn strength have been confirmed as being sensitive to and influenced by the net sum of positive and negative interrelationships occurring between the fiber measures involved. The net sum of positive interrelations toward yarn strength increases with increasing staple-length of cotton, being greater when fiber strength  $1/8$ " gauge is included in the analysis than fiber strength "0" gauge.



Under nine very different sets of conditions, the estimates of yarn-strength variance explained on the basis of the net total of positive and negative fiber interrelations and effects agree well with the total interactions and residuals shown by the respective multiple correlation analyses. Such findings refer to average interrelationships and effects for large series of cottons. For such knowledge to be applicable and beneficial to cotton-quality evaluations, however, it must be translated into some kind of data or terms for individual samples. The most promising clue found to date associated with fiber interrelations is the 1/8"/0 gauge fiber strength ratio. The mean ratio values have been found to vary from 1.06 to 1.33 for the respective varieties of American upland cotton studied and to 1.57 for Pima S-1 of American Egyptian cotton. Such fiber strength ratio values generally increase in size with increasing staple length but some exceptions have been observed. These exceptions are in line with the recent introduction of new and the discontinuance of old varieties.

(MQ 3-17)

#### IV. Relation of Spinning Performance of Cotton to Color Grade.

This research is being done under contract with Texas Technological College. Processing was begun on the cottons selected from the 1960-61 crop in accordance with the spinning plans developed under the provisions of the contract. After spinning approximately one-third of the bales, it was discovered that difficulties had developed in both processing and air-conditioning equipment, resulting in some unreliable results. The contractor suggested that the cottons selected from the 1960-61 crop be removed from this study and that cottons from the 1961-62 crop be included. This suggestion was approved by the parties concerned. The difficulties discovered in the processing and air-conditioning equipment have been corrected, and cottons from the 1961-62 crop have been obtained to substitute for all of the 1960-61 lots. Processing should get underway very soon.

(MQ 3-13(C))

V. Development of Small-Scale Spinning Test. Spinnable limits tests have been made in several studies during the year paralleling the large-scale spinning tests for evaluating the effects of harvesting and ginning conditions on processing performance. In general, the spinnable limits yarn number as calculated from the small-scale tests have shown good agreement with the large-scale test in ranking the cotton as to its spinning efficiency. However, there were a few inconsistencies noted. These inconsistencies were noted when the



spinnable limits values were used in ranking cotton as compared to the ranking attained by the large-scale test when spinning 40's yarn.

When these same cottons were spun into 50's yarn, by the large-scale test, the ranking as to spinning performance were in good agreement by the two methods. In other words, the large-scale test reversed the ranking of spinning performance of the same cottons when the rankings from 40's yarn were compared with the rankings obtained from the 50's yarn.

In studying these data where the inconsistencies occurred, it appears that an analysis of each of the yarn sizes spun to give data for calculating the spinnable limits value can indicate when a reversal will be obtained in the rankings of cotton by the large-scale test when spinning two different yarn numbers.

These findings are being published in an AMS Report entitled "Evaluation of a Small-Scale and Large-Scale Cotton Spinning Performance Test."

#### VI. Elastic Energy as an Indicator of Spinning Potential of Cotton.

Using an Instron tester and various methods of specimen preparation and mounting, some testing techniques for making measurement of compressional properties of bulk cotton have been found which give good repeatability of results. Bulk cotton samples representing pronounced differences in ginning treatments, varietal fiber characteristics, and environmental conditions during growth have been selected from three ginning-spinning studies and tested for compressional energy, compressional resilience and other related compressional properties. The data from these tests have been analyzed and a report is being written showing the following results:

(a) Within a single picking of cotton from the same field, the energy required to compress a given weight of bulk cotton to a given volume increased as the Shirley Analyzer nonlint content decreased and as the moisture level during ginning decreased.

(b) When a wide range of cotton samples of different varieties and origins are included in the same test, neither manufacturing performance nor product quality can be predicted from compressional property measurements. The differences between the different cottons tested exceeded the differences that were induced by severe ginning treatments.

(c) It has also been found that within a sample of cotton compressional resilience as measured by percent work recovery is a measure of fiber cell-wall development, but level of resilience varies widely between different varieties of cotton.  
(MQ 3-6)

B. Objective measurement of quality of cottonseed

1. Determination of Moisture and Oil Content. Rapid oil and moisture meters were field tested for the third year. Tests were made at Lubbock and Abilene, Texas, during the 1961-62 season. This information and the data compiled in three previous seasons (at Lubbock, Texas, Waxahachie, Texas, Memphis, Tennessee, and Clarksdale, Mississippi) are undergoing statistical analysis and a report is being prepared for publication. Data indicate that the meters for quick determination of oil and moisture are sufficiently accurate for use in a small lot grading system for cottonseed. A new rapid method for determination of neutral oil was developed. The method involves the use of activated alumina to remove free fatty acids. Compared with the official method using cottonseed from the Memphis area, the standard error of difference was  $\pm 0.25$  for the two methods. For Lubbock cottonseed, the standard error of difference was  $\pm 0.10$ . Close agreement was also observed with Fresno, California, seed.

(MQ 3-5)

2. Rapid Determination of Free Fatty Acids. An index of the quality of cottonseed oil is its free fatty acids content. Conductivity measurements of the ammonium salts of these acids in orthodichlorobenzene has not been possible due to formation of an unstable ammonium salt of gossypol. A possible solution to this problem was the utilization of petroleum ether extracts since references in literature indicate that gossypol is not extracted by this solvent. Use of this solvent soon disclosed discrepancies, especially of far western cottonseed, indicating that gossypol was being extracted in amounts that would interfere with conductivity determinations for free fatty acids. In several cases the amount of gossypol extracted would definitely affect the total oil content determination. This observation had not been made previously.

Preparation of the ammonium-butanol electrolyte was improved. Previously this electrolyte had to be prepared weeks in advance. This instability was found to be due to absorption of atmospheric  $\text{CO}_2$  and subsequent formation of ammonium carbonate. The reagent may now be prepared in 30 hours by bubbling air (atmospheric  $\text{CO}_2$ ) in the solution until equilibrium is reached.

PUBLICATIONS REPORTING RESULTS OF USDA AND  
COOPERATIVE RESEARCH

Objective Measurements and Evaluation of Quality

- Burley, S. T., Jr., and Mullikin, R. A. 1962. Spinning performance evaluation of cotton. "Effect of Yarn Size on Spinning End Breakage," Textile Bulletin, Vol. 88, No. 2, p. 63, February 1962.
- Pentzer, W. T., Newton, F. E., and Burley, S. T., Jr. 1962. Effects of multiple lint cleaning on cotton fiber and spinning properties, Cotton Gin and Oil Mill Press, p. 30, July 21, 1962.
- Baumann, L. A. 1962. Predicting quality of stored cottonseed oils, MRR 523 - AMS - USDA, February 1962.



AREA NO. 8 WOOL AND MOHAIR -- MARKET QUALITY

Problem. Wool varies widely in quality factors that affect its value and use. Impurities in grease wool are a major problem, and an objective method of estimating the clean yield of grease wool is badly needed. Also needed are procedures and instruments to measure accurately the fineness and length of fibers. Animal fibers in raw or manufactured form are subject to damage by fabric insects, which are estimated to cause annual losses of about \$350 million. Effective and safe control methods are needed to be used in homes, retail stores, warehouses, woolen mills, and manufacturing plants to control the fabric insects that infest the premises. Improved fabric treatments and methods of application are needed to prevent the extensive feeding damage by insects. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information leading toward the development of better preventive treatments, and as an aid to the Western Utilization Research and Development Division in its program on the improvement of wool by molecular modification.

USDA PROGRAM

The Department has a continuing long-term program at Savannah, Georgia, involving entomologists and chemists engaged in applied research on the protection of wool, mohair, animal hair, and articles made of these fibers against insect damage while in marketing channels, in military uses, and in the home. The research is conducted in cooperation with the Armed Forces Pest Control Board, the Western Utilization Research and Development Division, the Piano Technicians Guild, and various industry groups. Some work on quality evaluation of wool is also done.

The Federal scientific effort devoted to research in this area totals 2.4 professional man-years. Of this number, about 0.1 is devoted to quality evaluation of wool.

Four line projects were discontinued during the reporting period. These were BS 1-55, "Development and Improvement of Formulations and Application Techniques for EQ-53 and Similar Mothproofing Compounds;" BS 1-56, "Development of Measures for Protecting Textiles Against Fabric-Insect Damage while Stored in Containers;" BS 1-57, "Evaluation under Storage Conditions of Fabric Treatments for Protection Against Insect Damage;" and BS 3-60, "Evaluation Procedures for Wool."

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State Experiment Stations in 1961 reported 1.3 professional man-years on objective measurement and evaluation of quality of wool. Regional Project WM-23, Marketing Wool, is a part of this coordinated research program. Major emphasis is placed on evaluation of the relationship of objective measurements of wool quality factors to processing performance and market value of specific grades and types of western wools.

Industry and other organizations, specifically textile companies and firms in the wool industry, have some research and development personnel working on

aspects of wool quality evaluation. The results of much of this work are kept confidential. Estimated annual expenditures are equivalent to approximately 5 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement and evaluation of quality.

1. Evaluation Procedures. This project has the objective of developing improved procedures for evaluating the market quality of wool. Measurements that were carried out on the gamma-ray emission of grease wool fleeces sheared in Spring 1960 and Spring 1961 disclosed that potassium-40 was the major source of the emitted radioactivity. Cesium-137, a fission product arising from radioactive fallout, occurred in variable amounts in these fleeces. The scouring process removed the bulk of the gamma-ray emitters present in grease wool. The potassium-40 and cesium-137 emission rate did not appear to be closely related to the total content of impurities in grease wool fleeces. Measurements made of grease wool sheared at Beltsville in November 1961 revealed the presence of mixed fission products from fresh fallout, in contrast to wool which had been sheared on earlier occasions, in which cesium-137 and potassium-40 were the principal gamma-ray emitters. The presence of these mixed fission products in appreciable amounts complicated the situation and made it more difficult to obtain potassium-40 measurements.

The wool staple-length recording device for measuring length of grease wool staples which was developed under contract was field tested by personnel of the Livestock Division Wool Laboratory. The performance of this machine, which measures 100 staples of 3-inch wool in about 12 minutes, was found to be very satisfactory. In repeat measurements, the average seldom varied more than 0.03 inch and never as much as 0.10 inch. (BS 3-60)

### B. Prevention of insect infestation.

1. Insecticide Evaluation. Diazinon applied to woolen cloth under simulated dye-bath conditions was highly resistant to removal by 10 drycleanings. After these cleanings, the treatment in the cloth still prevented all warp damage and all but very light to light nap damage by fabric insects in the standard forced-feeding test. Telodrin applied in the same manner was even more resistant to removal by 10 drycleanings or launderings, preventing all warp damage and all but very light nap damage. (BS 1-55)

A formulation containing DDT, Strobane, and lindane, and another containing only DDT and lindane were tested extensively in the laboratory as potential mothproofing treatments for the felts in pianos. After satisfactory performance in these tests, they were recommended to the Piano Technicians Guild for evaluation of practical performance when used in pianos in homes. This applied test is still in progress by members of the Guild. (BS 1-55)

Studies with emulsifiable concentrates of DDT formulated with various surfactants showed that none of the formulations was significantly superior to EQ-53. Studies on the application of DDT to woolen cloth under simulated dye-bath conditions showed that a relationship exists between immersion time and the



resistance of the DDT deposit to removal by laundering or drycleaning. The longer the immersion period, the greater is the persistence. Preliminary studies on incorporating DDT in a fluorochemical formulation and making application to woolen cloth in a cold water dip in accordance with the manufacturer's directions appeared to increase the resistance of DDT to removal by laundering or drycleaning. Further tests in which simulated dye-bath treatment was made showed an increased fixation of the mothproofing to the wool. (BS 1-55)

Studies were conducted on the application of insecticides to woolen cloth in combination with a number of textile treatments to determine the effectiveness of these combinations in increasing the persistence of the insecticidal deposits. These included interfacial polymerization (IFP), shrink-proofing and wool-strengthening treatments, epoxy-polyamide applications, and stain-resistant and water-repellent finishes. None of the combinations were sufficiently superior to the insecticide alone to warrant further evaluation. Several of the treatments without the insecticide protected the cloth against insect feeding in precleansing tests, but the protection did not persist after the cloth was subjected to any cleansings. Preliminary studies conducted with dye-bath applications of emulsifiable concentrates of DDT formulated with various surfactants showed that a cationic surfactant by itself may be a very effective mothproofing. One, which contained 98 percent of cetyl dimethyl benzyl ammonium chloride, did not completely protect the cloth in precleansing tests but after five drycleanings was as effective as the insecticidal treatment used as a standard. (BS 1-55)

Laboratory biological evaluations were completed during the past two years with 114 compounds to determine their efficacy in protecting woolen cloth against fabric-insect damage. Two quaternary ammonium compounds, Ammonyx G and DME, demonstrated sufficient effectiveness to warrant followup studies as mothproofers. These compounds are normally used as emulsifiers, germicides, or deodorants. Residues, deposited by immersing the test cloth in an emulsion bath, showed excellent persistence during drycleaning. The results of preliminary evaluation tests with aldrin and allethrin also indicate need for followup evaluation tests. (MQ 1-26)

2. Insecticidal Control. Military uniforms packed in heat-sealed envelopes made of polyethylene-laminated kraft paper and placed in wooden boxes remained free of insect damage during two years of storage with continuous exposure to fabric insects. The envelopes remained tightly sealed and impenetrable, preventing entry and damage by the fabric insects whether the boxes contained lindane or not. The boxes themselves provide no protection against insects. Studies to determine the length of time required to kill fabric insects exposed to various vapor concentrations of DDVP showed the larva of the webbing clothes moth was the most susceptible, followed in order by the larva of the furniture carpet beetle and the black carpet beetle. (BS 1-56)

Tests in which rolls of cloth treated with DDT during the sponging process have been constantly exposed to a heavy insect infestation showed that this treatment continued to protect the cloth satisfactorily after 15 years. Rolls of cloth treated with DDT by QM during sponging, and then packaged in cardboard boxes, were completely free of insect damage after 10 years' storage in an infested area. The third annual inspection of the test on the evaluation of



dielldrin as a dye-bath mothproofing treatment revealed that a few areas of nap damage varying from very light to moderate and slight warp damage were present on a few rolls. This treatment, however, continues to provide a very high degree of protection. (BS 1-57)

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Objective Measurements and Evaluation of Quality.

Kulwich, R., Hourihan, M. E., Terrill, C. E., Beckner, W. N., and Burkle, J. S. 1961. Natural fission product - gamma radioactivity of individual grease wool fleeces. Proceedings of Conference on Use of Radioisotopes in Animal Biology and the Medical Sciences, Mexico City, pp. 47-56. (BS 3-60)

##### Prevention of Insect Infestation.

Bry, Roy E., McDonald, L. L., and Davis, Dean F. 1960. Preliminary evaluation of lindane and heptachlor crystals for protection of crated furniture against insect damage. Journal Economic Entomology 53(5), pp. 966-967. (BS 1-56)  
Stored-Product Insects Branch. 1961. Clothes moths and carpet beetles. How to combat them. Home and Garden Bulletin No. 24 (Revised), USDA, 12 pages. (MQ 1-26)

AREA NO. 9 POTATOES -- MARKET QUALITY

Problem. The problems arising from the number of potato varieties grown, areas of production, seasons of harvest and special storage and handling requirements for specific uses require a continuing program of research on handling, storage, transportation, physiology, wastage control and quality measurement. Current emphasis on processing has created special problems in prolonged storage at elevated temperatures and protection from low temperatures in transit. This has substantially increased the need for research on the control of moisture loss and the reduction of bacterial and fungal decay. Higher temperature storage also involves control of sprouting, with increased emphasis on chemical sprout inhibitors. There are also major problems in the area of quality measurement. Objective indices are needed to identify quality factors that are important for specific product usage. Also needed are non-destructive methods and instruments for detecting and rejecting potatoes with internal disorders during grading.

USDA PROGRAM

The Department has a continuing long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California station. The studies at Beltsville involve specialized storage problems and basic research. Studies on market diseases are conducted at Chicago and New York City.

The Federal scientific effort devoted to research in this area totals 9.5 professional man-years. Of this number, 0.5 is devoted to objective measurement of quality; 1.3 to handling and packing; 2.3 to storage; 2.0 to quality maintenance during transportation; 1.0 to post-harvest physiology; 1.9 to post-harvest disease control, and 0.5 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 7.8 professional man years as follows: objective measurement and evaluation of quality 1.1, handling and packaging 2.3, storage and transportation 4.3, and post-harvest disease control 0.1. Much of the work on handling and packaging is concerned with prepeeled potatoes.

Industry and Other Organizations: Potato processors devote approximately 2 man-years on biochemical changes in potatoes during storage as affecting suitability for processing. Chemical companies do a limited amount of research (approximately 2 man-years) on developing, formulating, and evaluating sprout inhibiting chemicals.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement of quality

1. Determining Susceptibility to Bruising. An impact instrument was developed in cooperation with ARS to measure susceptibility to bruising. Growers in the Red River Valley complained in the fall of 1961 that most Red Pontiacs were too tender to handle without bruising or cracking whereas Norlands could be handled normally without trouble. The impact instrument showed Red Pontiacs were two to three times as susceptible to bruising as Norlands. (MQ 3-40 pending)

### B. Quality maintenance in handling and packaging

1. Mechanical Injury Incident to Sizing Potatoes into Storage. In the Red River Valley, more bruising occurred in Norland potatoes sized into storage than those not sized but the bruising was largely confined to non-grade defects. About twice as many non-grade defects occurred in the sized potatoes as in unsized. As expected, potatoes in the two larger size groups had about two to three times as many non-grade defects as the small size group. (Line project being developed)

### C. Quality maintenance in storage

1. Influence of Storage Temperature on Processing Quality of Potatoes. Twenty-four 1 ton capacity boxes were filled at East Grand Forks, Minnesota, with Irish Cobbler, Kennebec, Red Pontiac and Snowflake potatoes. Equal quantities of each variety were stored at 40°, 45°, and 50° F. The potatoes stored at 45° and 50° were treated with isopropyl N-(3 chlorophenyl) carbamate (CIPC) to inhibit sprouting. At monthly intervals for 10 months, 300-lb. lots were removed from storage for pilot-plant processing into potato flakes and slices. The data on quality of the products are not yet available. (MQ 2-69 pending)

2. Effect of Methods and Rates of Ventilation on Quality of Maine Potatoes. Maine potatoes stored with no forced air circulation for 154 days at 38° F., and 85 percent relative humidity lost approximately 6 1/2 percent in weight. Maintaining the same temperature and humidity at an air flow of 8 fpm increased weight loss to about 8 1/2 percent. By increasing the humidity to 95 percent the weight loss at 8 fpm was about 7 percent.



Instrumentation is being developed, in cooperation with the University of Maine, to measure low airflow velocities which occur within a bin of potatoes. Preliminary tests with the instrument show that most of the air flows along the outer edges of the bin and little air is actually forced through the top center of the pile even at relatively high input rates. (MQ 2-35)

3. Deep Bin vs. Pallet Box Storage. Although data on weight losses and temperatures indicated relatively slight differences between the two systems, more total bruising resulted in deep bin storage than in pallet box storage in Maine. Approximately 9.6 percent of the tubers from the deep bin were classified as being damaged (5-10 percent waste) whereas only about 5 percent of the tubers in the pallet box were damaged. Serious damage (over 10 percent waste) was evident in 2 percent of the tubers from the bin whereas about 1 percent of the potatoes in the pallet boxes showed this condition. (MQ 2-39)

Storage of potatoes in pallet boxes reduced the amount of pressure bruising and internal black spot as compared with potatoes stored in deep bins. In samples from deep bins approximately 14.5 percent of the potatoes had pressure bruised areas whereas in pallet boxes 7.7 percent of the potatoes showed this condition. After a holding period of 10 days, 1.1 percent of the potatoes from deep bin storage had developed internal black spot. None of the potatoes from pallet boxes had developed internal black spot. (MQ 2-37)

4. Internal Sprouting. Tests were initiated at Beltsville in April 1961 to determine the causes of the serious losses associated with internal sprouting of potatoes during the 1960-61 season. Maine-grown Katahdin potatoes previously stored at 40° F. were treated with varying concentrations of isopropyl N-(3 chlorophenyl) carbamate (CIPC) in aerosol form. The amount of internal sprouting decreased as the concentration of CIPC was increased and the untreated check lots held at the same temperatures as treated samples had more internal sprouting than treated lots. Storage temperature was the most important factor in the development of internal sprouting. The percentage of tubers with internal sprouting after 5 months' storage at different temperatures were 50° - 1.5%, 60° - 14.4%, 70° - 9.8%.

Three varieties tested during the 1961-62 season showed a widely different response. Irish Cobbler samples had considerably more internal sprouting and averaged 31% in the untreated lots stored at 60° F. as compared to 13% for Kennebec and 7.5 % for Katahdin. Further tests with storage temperatures using the Katahdin variety showed the following percentages of internal sprouting: 50° - none, 55° - 0.3%, 60° - 13.6%, 65° - 19.6%, and 70° - 10.0 %.

In tests the first year potatoes treated with CIPC after sprouting had started, had slightly higher percentages of internal sprouting but differences were not significant the second year. Samples receiving two aerosol applications of CIPC about 2 weeks apart had somewhat less internal sprouting than those receiving only one application. Potatoes dipped in 0.5% suspension of CIPC did not develop internal or external sprouts during 5 or 6 months of storage. (MQ 2-31)

#### D. Quality maintenance during transportation

1. Transit Temperatures of California Potatoes for Chipping. Early-season unwashed Kennebec potatoes shipped by rail from California to midwestern chip plants are usually shipped with vents open and no ice, unless potato temperatures at loading are extremely high. A shipment in which initial temperatures were 75° F. encountered average outside air temperatures of 90° maximum and of 63° minimum enroute. Average potato temperatures in transit were 68° when the vents were partly open (vents on irons) and 67° when the vents were fully open. The color of chips made with potatoes from both cars at arrival was good. Decay was negligible.

A shipment of washed potatoes that had a temperature of 95° at loading was iced with 1 ton of ice in each bunker and shipped with vents open. This shipment encountered average maximum and minimum temperatures of 93° and 64°, respectively. Although the average transit temperature (71°) of the potatoes was satisfactory, decay was excessive (65 to 68%), probably due to the high initial temperature and high moisture conditions resulting from washing.

Chip color, in relation to transit temperatures, was studied in the laboratory. Kennebecs held at 70° F. for simulated transit periods yielded chips with optimum color. Holding at 75° did not improve color and increased the amount of surface mold. Chips made from tubers held at 65° showed significant darkening and those from tubers held at 60° were so dark that they were on the borderline of acceptability. (MQ 2-55)

2. Effect of Low Temperatures on Seed Potatoes. The seed value of four varieties of potatoes, exposed to freezing or near freezing temperatures, was tested in plantings in Maine, New York, and Delaware. Red Pontiac seed potatoes from East Grand Forks, Minnesota, and Katahdin, Irish Cobbler and Pungo seed potatoes from Aroostook County, Maine, were stored and treated at Beltsville, Maryland. All potatoes were stored at 40° F. before treatment and were held at 50° for 2 weeks after treatment before planting. Treatments were: (1) 40° F. continuously (standard), (2) 30° one day, (3) 30° ten days, (4) 25° F. one day (supercooled without freezing), and (5) 25° F. one day (with freezing symptoms produced by jarring).

Unless freezing (with visible symptoms) occurred in the seed tubers, freezing or near-freezing temperatures for up to 10 days did not adversely affect emergence, growth, or yields. This work has been completed. (MQ 2-19)

#### E. Post-harvest physiology (Beltsville)

##### 1. Phenolic Constituents and Their Relation to After-Cooking

Discoloration. The phenolase enzyme system was found to be present in potato cells in a soluble and also in a bound form. No specific localization within the cell could be established. Wounded tissues rapidly accumulated polyphenols consisting primarily of chlorogenic acid. Phenolase activity was also found to be greater in tissues that had been wounded. The tissues with accumulated polyphenols were somewhat darker in color after cooking than corresponding tissues with lower concentrations of polyphenols. This work has been completed. (BS 2-86)

2. Phenolase Enzyme Activity. The phenolase enzyme which causes the discoloration of freshly cut or injured potatoes was found widely distributed in various extracts of potatoes. When potato tissue was macerated a considerable portion of the enzyme was soluble in the water extract but some remained bound to the mitochondria and other small particles within the cell. Phenylthiourea in very low concentrations completely inhibited phenolase activity but had no effect on respiration of potato slices. No evidence could be found to indicate that phenolase acted as an important terminal oxidase in respiration or is involved in suberin formation. (Pioneering Laboratory)

3. Suberin Formation. A fluorescent microscope was used to study suberin formation in potato tissues. Light had no measurable effect on suberin formation. Oxygen was required but 2 percent was almost as effective as the normal atmospheric 20 or 21 percent. Numerous chemicals were added to the tissue slices to test their effect on suberin formation. Only (1) shikimic acid (2) eugenol or ferulic acid with hydrogen peroxide significantly increased suberin formation. (Pioneering Laboratory)

#### F. Post-harvest disease control

1. Pre-Storage Washing. Lenticel infection studies were initiated in Maine to determine whether maturity, interval between washing and harvest or storage temperatures prior to washing influenced the amount of lenticel infection in Katahdin potatoes. Maturity did not appear to affect the amount of lenticel infection. However, storage at 50° F. and approximately 85 percent relative humidity for 2 weeks or longer prior to washing reduced infection. All lots of washed potatoes showed more lenticel infection than unwashed potatoes.



Histological studies showed more suberin development beneath the lenticels of tubers stored at 50° F. than of tubers stored at 38° F. Suberin began to develop after approximately one week at 50° F. while tubers stored at 38° showed only slight evidence of suberin after 3 weeks storage. (MQ 2-39)

2. Decay of Cut-Seed Pieces as Influenced by Previous Storage Temperature. Slices from Irish Cobbler, Sebago, Katahdin and Kennebec tubers stored at Beltsville for 4 months at 32° or 34° F. developed approximately the same amount of suberin and periderm at 70° as slices from tubers of the same varieties stored at 40°. However, slices from Pungo tubers stored 4 months at 32° developed slightly less suberin at 70° than slices from tubers stored 34° or 40°. They developed no periderm. Slices from tubers of each variety stored at 32° F., especially after only 2 days healing before inoculation with Erwinia carotovora, developed more decay than slices from tubers stored at 34° or 40°. More decay developed on Pungo slices than on slices of other varieties. These studies emphasize the need for avoidance of prolonged storage of seed potatoes at very low temperatures.

Sprouts emerged much more rapidly from seed pieces from tubers stored at 40° F. than from seed pieces from tubers stored at lower temperatures. Emergence was slowest from seed pieces from tubers stored at 32°. Almost a perfect stand existed 6 weeks after planting regardless of variety or storage temperature. The work on precut seed has been completed. (MQ 2-5)

3. Relation of Oxygen and Carbon Dioxide to Decay. Studies at Beltsville of the effect of O<sub>2</sub> and CO<sub>2</sub> concentrations on bacterial decay of potatoes were continued. Oxygen concentrations below 6% increased the penetration of bacterial soft rot isolates into the slices. Indications were also obtained that decay of whole tubers and slices was increased when CO<sub>2</sub> was allowed to build up within the chambers. Sections from slices held in 6% or higher oxygen concentrations had strong fluorescence indicative of suberin formation when examined under an ultraviolet microscope. Those from 1% O<sub>2</sub> had only slight fluorescence. Periderm formed with O<sub>2</sub> concentrations as low as 8% but not below that. (MQ 2-3)

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## AREA NO. 10 POULTRY PRODUCTS -- MARKET QUALITY

Problem. New technological developments in the poultry industries have created many problems relating to the market quality of poultry and egg products. The introduction of highly mechanized equipment and new techniques in processing have had variable effects on the absorption and retention of moisture of ready-to-cook poultry, on the contamination of poultry and egg products by spoilage microorganisms, on physical damage to poultry carcasses, and on sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more precise information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

### USDA PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, and at Athens, Georgia, in cooperation with the Georgia Experiment Station and through a research contract with the University of California, Davis, California, on the effect of various disease syndromes on the wholesomeness of market poultry.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years, about equally divided between objective measurements and evaluation of quality, and handling and packaging. Studies on the use of paper containers for ice-packed poultry (BS 2-39) and the contract study of disease agents in dressed poultry (BS 3-65) were terminated during the period.

A P.L. 480 grant with The Ministry of Agriculture, Spain, provides for a study of the relation of changes in chemical and biological properties of lysozyme to changes in quality of shell eggs held in cold storage. Its duration is for 3 years, 1960-1963, and involves P.L. 480 funds with a \$17,094 equivalent in Spanish pesetas.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 6.1 professional man-years divided as follows: Objective measurements and evaluation of quality 1.9, handling and packaging 2.7, storage 1.4, and transportation 0.1. Under objective measurements and evaluation of quality are studies on yolk lipids and albumin constituents, odor absorption, and taste panel evaluation of desirability of eggs in relation to the quantity of lipids in the yolks. Handling and packaging include packaging materials, techniques for handling and applying films including edible forms. Storage work includes effects of storage conditions, of slaughtering, and of freezing methods, sanitation procedures, identification of microorganisms responsible for spoilage and methods for their control.

Industry and other organizations conducting research on poultry products include several firms manufacturing convenience food items that are investigating factors affecting the quality of poultry meat. Their estimated annual expenditures are equivalent to approximately 5 professional man-years. A few chemical companies are engaged in the formulation of chemicals or production of bacteriostatic agents to retard decline in quality of poultry meat and to minimize microbial spoilage and deterioration of quality of shell eggs. Estimated annual expenditures are equivalent to approximately 5 professional man-years. The various poultry industry associations, such as the Institute of American Poultry Industries, the Poultry and Egg National Board, and the National Turkey Federation, support research on quality evaluation and maintenance of poultry products. Estimated annual expenditures are equivalent to approximately 5 professional man-years.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

#### A. Objective measurement and evaluation of quality

##### 1. Assessing the Sanitary Quality of Commercial Egg Solids.

During the past year, work was continued in an effort to establish a sound basis for using the Group-D streptococci (enterococci) as indicators of the sanitary quality of egg products. Samples of egg white solids from the USDA laboratory in Chicago, as well as several samples from commercial firms were examined for coliforms, salmonellae, enterococci, and total viable bacteria. Results of these tests indicated that the enterococci were the predominant



organisms in these samples. Identification of a number of isolates from the enterococcus plates indicated that Streptococcus faecalis var. liquefaciens is the most common contaminant of these products. The enterococci were found to be most consistently resistant to the laboratory drying process. Work was also carried out to improve methods for the direct microscopic count (DMC) of bacteria in egg products. Modifications of the Moats' stain which utilizes periodic acid, bisulfite solution, and toluidine blue (PBT stain), developed for use with dairy products, was found to produce a better color differentiation between bacteria and egg melange. These modifications were necessary to compensate for the differences in viscosity of milk and egg products. Further work along this line is necessary before a completely satisfactory stain is developed.

(MQ 3-31)

2. Relation of Lysozyme to Egg Quality. Microbiological and chemical studies of shell eggs held in cold storage for various periods of time were carried out under a P.L. 480 grant.

Results obtained indicate that shell eggs stored at 0° C. and 90% relative humidity for periods up to 60 days were contaminated primarily with yeasts and molds, with no evidence to indicate the presence of bacteria. In accelerated deterioration tests it was found that (a) the rate of thinning of buffered egg white (pH7) was greater than that of unbuffered, (b) viscosity of egg white decreased with time concomitantly with an increase in the percentage of thin white, these changes being more pronounced in buffered samples, (c) lysozyme activity was higher in buffered eggs than in unbuffered, (d) lysozyme activity decreased slightly with time, and (e) two zones of maximum lysozyme activity appear (pH6 and pH8.4).

(E 25-AMS-5(a))

3. Antemortem and Postmortem Inspection Studies. This study to ascertain the quantitative and qualitative spectrum of infection of dressed poultry by human pathogens and to evaluate the efficacy of antemortem inspection as a supplement to postmortem inspection of poultry was completed this year.

Previously unreported results of the study are (a) a general relationship was found between condemnation rate and quality of overall husbandry practices in chicken fryer and turkey flocks; (b) the tissues of market poultry being routinely processed for



human consumption harbor coagulase positive staphylococci, coagulase-negative staphylococci, beta, alpha, and gamma hemolytic streptococci, Pseudomonas sp., Coliforms, Proteus sp., and Bacillus species at various incidence levels; (c) tissues did not contain the following pathogens; Brucella sp., Erysipelothrix rhusiopathiae, Listeria monocytogenes, Pasturella multocida, Clostridium perfringens, Salmonella sp. or Paracolonobacterium arizonae; (d) the intestinal contents of such poultry harbored Salmonella species and/or Paracolonobacterium arezonae contaminating unknown numbers of carcasses during processing. (e) Evidence was obtained which indicated a positive correlation between the gross pathology of chicken fryers and the presence of Salmonella species in the intestinal tract as well as the presence of coliforms in the liver of adult chickens; (f) no correlation was found between gross pathology of livers of chickens and turkeys and the presence of pathogens in the liver tissue; (g) some evidence was obtained to indicate a positive correlation between gross pathology of such a nature and extent as to be cause for condemnation of livers of chickens and turkeys, and the presence of some form of histopathology; (h) no correlation was found between the presence of specific pathogens and the presence of specific histopathology lesions in livers of chickens and turkeys. In addition to the above, a quantitative study of Salmonellae in the intestinal tract of market poultry yielded evidence indicating that the feces of turkeys artificially infected within the previous 6 weeks may contain up to  $10^{3.5}$  Salmonella organisms per gram. This gives some concept of the possible magnitude of the contamination potential such birds would yield if processed.

(BS 3-65)

4. Effect of Various Disease Syndromes on Wholesomeness of Market Poultry. This study was initiated this year under contract with the University of California. Data to be developed during this study will aid in determining the relationship of the visible lesions which must be used by poultry inspectors to the various stages of the disease syndromes most commonly found in poultry and should result in more clearly defined criteria for judging the wholesomeness of market poultry.

(MQ 3-22(c))

5. Evaluation of Bone Darkening in Fryer Chickens. Darkening of bones, after cooking, has been an important factor affecting the consumer acceptance of frozen fryer chickens. A study was initiated to compare the incidence and degree of bone darkening of

frozen and unfrozen fryers and to develop practical methods for evaluating this defect. Thigh bones from cooked chickens (both frozen and unfrozen) were evaluated for intensity of bone darkening by visual comparisons of the bones to a series of nine Munsell chips ranging, in value, from white to black. Photographs of the individual bones were also taken in preparation for further studies to develop practical methods for rating bone darkening. The chickens, which had been reared on diets containing various levels of calcium and phosphorus, were obtained through the cooperation of the Poultry Branch, AHRD.

The extent and intensity of bone discoloration was greater in thighs which had been frozen and thawed before cooking than in cooked unfrozen thighs, although the difference was small. For both frozen and unfrozen thighs, there was a direct relationship between the calcium-phosphorus ratio and the severity of the bone discoloration.

(Exploratory work - no line project)

B. Quality maintenance in handling and packaging

1. Quality Changes of Ice-Packed Poultry in Paper Shipping Containers. Bacteriological evaluations were made of whole and cut-up chickens shipped in corrugated paper shipping containers and wirebound crates. Numbers of mesophilic and psychrophilic bacteria on poultry in corrugated paper containers were similar to those on poultry packed in wirebound crates after shipping about 150 miles and storage at 34° F. for 12 hours. Lining either the inside or coating the outside of a corrugated container with aluminum improved the container's insulating properties only slightly. Use of a kapok liner was more effective for inhibiting heat transfer.

Work on this project was terminated because of the unavailability of corrugated fiber containers which can stand up under laboratory storage tests.

(BS 2-39)

2. Influence of Polyphosphates and Other Compounds During Chilling on Quality of Eviscerated Poultry. A study of the effect of phosphate treatment on carcass weight changes and organoleptic quality of cut-up chicken was completed. Moisture uptake by eviscerated broilers during a 6-hour chill period in slush ice containing 7, 8, or 10 ounces of phosphate per gallon was,



respectively, greater than, no different from, and less than that by birds chilled in solutions containing no phosphate. Phosphate treatment reduced weight loss of cut-up carcasses during storage, resulted in an increase in juiciness of dark meat, and an increase in tenderness of white meat but did not significantly affect flavor.

(MQ 2-41)

The influence of a number of variables on the moisture changes in fryer chicken carcasses during chilling in the presence of polyphosphates and other compounds was also investigated. The effect of temperature and pH of coolant, duration of chilling, period of air agitation of coolant, method of chilling, concentration of phosphate mixture, and concentration of NaCl on moisture absorption and retention were determined. Analysis of the data is in progress.

(MQ 2-10)

3. Bacteriological Studies of Commercial Poultry Processing. A study to determine the effect of different cooling methods on the bacterial condition of fryer chicken carcasses was completed. Numbers of bacteria per milliliter of chill water increased significantly during 6-hour standard tank chilling (non-agitated). Bacteria counts of breast skin surface increased significantly during standard tank chilling, did not change significantly during chilling in an oscillated-vat, low agitation continuous chiller, and decreased significantly during chilling in a counter-flow tumble, higher agitation continuous chiller.

(MQ 2-10)

A survey of bacterial contamination during cutting and packaging of chicken fryers at retail stores and in commercial plants was completed. Total bacterial counts on uncut chicken were low in both plants and stores, but increased approximately sixfold in plants and eightfold in stores during cutting and packaging. Continuous spray washing of conveyor belts with chlorinated water in plants, thorough cleaning of meat blocks in stores, and the presence of adequate hand-washing facilities in both locations were the most important factors in preventing bacterial-buildup on cut-up parts.

(MQ 2-41)

A preliminary study of airborne bacteria in the atmosphere of poultry processing plants was carried out. In one plant, the



dressings areas were the most heavily contaminated. A more thorough study of airborne microorganisms is underway.

(MQ 2-6)

4. Basic Studies on Cooling of Eviscerated Poultry. Two studies were carried out in cooperation with the Transportation and Facilities Division. In one, the thermal conductivity and density of muscle and skin tissue of broilers and hens were measured to obtain basic data needed in the design and evaluation of poultry chilling equipment. No significant effect on thermal conductivity was produced by variations in percent moisture, percent fat, or weight of carcasses from which samples originated. The other study involved the determination of the rate of cooling chickens in 32° F. water. During this study a technique for thermocouple placement in broiler carcasses was developed that resulted in greater accuracy during recording of carcass temperatures. This study has been completed and a manuscript is being prepared for publication.

(MQ 2-41)

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AREA NO. 11 TOBACCO -- MARKET QUALITY

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and use. The price support program has resulted in a large build-up of stocks, some held for as long as 7 years, about twice the normal period for storage and aging. The long-term storage and compact nature of the material as stored make insect control difficult. Any measures now available for use only hold insect populations in check and do not prevent or reduce them. There is need for more effective measures that will eliminate insect populations in tobacco warehouses. Basic information on the ecology, physiology, and behavior of the insects is needed to provide information that can be used in developing measures that would prevent even initial infestations.

USDA PROGRAM

The Department has a continuing long-term program at Richmond, Virginia, involving entomologists engaged in both basic studies and the application of known principles to the solution of stored-tobacco insect problems in the marketing channels. The research is conducted in cooperation with farmers cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists whose research has cross-commodity application. The program is discussed in Area 13. Although much of the work on insecticide evaluation has a direct relation to stored tobacco, only a proportionate share of that effort has been allocated to Area 11.

The Federal scientific effort devoted to research in this area totals 3.8 professional man-years. Of this number, 0.5 is devoted to basic biology and ecology; 1.0 to insecticide evaluation; and 1.5 to insecticidal control at Richmond; 0.4 to insecticide evaluation at Savannah, and 0.4 to program leadership at Beltsville, Maryland. Three line projects were discontinued during the reporting period. These were BS 1-3 (Rev.), "Exploratory tests of new materials and new or improved methods for the control of insects in stored tobacco," BS 1-69, "The effect of time, temperature, and gas concentration on the cigarette beetle in the fumigation of tobacco," and BS 1-70, "Investigation of the behavior of gases to improve procedures in the fumigation of tobacco."

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations reported no work on Market Quality of Tobacco in 1961.

Industry. Several of the tobacco companies cooperate with the Department by providing labor, equipment, and materials for large scale tests; they make available their warehouses and literally millions of dollars worth of tobacco for experimental use. Estimated annual expenditures are equivalent to approximately 4 professional man years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation.

1. Basic Biology and Ecology. Studies on the effect of relative humidity on the development of the cigarette beetle indicated a definite breaking point between 50 and 60 percent relative humidity. Survival was poor below 50 percent. (MQ 1-7)

Black light was found much more attractive than incandescent light to the cigarette beetle. Black light intensity of 5.8 foot candles, at 2 feet was only slightly more attractive than 2.8 foot candles, but an intensity of 8.4 foot candles was significantly more attractive than either. Infrared light was less attractive than incandescent light. A 32-watt circular black light tube mounted in the throat of a suction light trap was the most effective arrangement tested. A more efficient light trap was designed and recommended for use in tobacco factories. It is being adopted rapidly by industry as a means of insect detection. (MQ 1-7)

Studies of the time of day during which the tobacco moth emerges showed that the heaviest emergence (52 percent) occurred between 2 and 8 p.m., but that emergence of the other 48 percent was rather evenly distributed throughout the remaining 18 hours. (MQ 1-7)

In studies of emergence of the cigarette beetle from tobacco, it was found that in artificially infested hogsheads, regardless of the intensity of the infestation, the first generation only penetrated to a depth of 1 inch, but the second generation penetrated to a depth of 3 inches; most of the beetles of the first generation emerged and only a very few reentered and remained in the tobacco; of the second generation a large number emerged and many reentered the tobacco and remained; approximately 40 percent of the beetles maturing in the tobacco of the first 2 generations (during the first year of infestation) never emerged from the hogsheads. This is the highest percentage of beetles not emerging ever recorded. The increasing percentage of beetles not emerging from the tobacco suggests that a new biological strain of the cigarette beetle may be developing that does not emerge from tobacco. This would not be surprising, since for years many of the beetles emerging have been killed by insecticides while those not emerging have every chance to survive and reproduce. Studies of this problem have been initiated. (MQ 1-7)

2. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area although much of the work is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

3. Insecticidal Control. A new and improved model of the fumigant applicator for use in tobacco warehouses was designed, built, and successfully tested with HCN. The new model is more compact, lighter, easier to handle, and equally as efficient as the pilot model. (BS 1-3 (Rev.))



An automatic DDVP aerosol dispensing system was developed and tested. This equipment proved highly efficient, even in air-conditioned tobacco factories. Results of tests were so satisfactory that the cooperating tobacco company immediately installed such equipment in most of their manufacturing plants. Further industrial-scale tests with DDVP in tobacco storage warehouses confirmed previous research indicating that this material is the cheapest, easiest, and most efficient control yet found for the tobacco moth. Against the cigarette beetle it is much less efficient. It kills the exposed beetles in the air space but does not control a beetle infestation in tobacco. A combination of regular applications of DDVP aerosol plus one fumigation gives effective and economical control of the cigarette beetle. As a result of this procedure, in 1960 the Flue-Cured Tobacco Cooperative Stabilization Corporation (with stocks of over 500 million pounds of flue-cured tobacco) obtained the best insect control in its history at a saving of more than \$40,000 in costs of insect-control measures as compared with costs in 1959. (BS 1-3 (Rev.))

Studies of insect repellents on paper liners for tobacco hogsheads showed definite repellency for 3 materials after 1 year of exposure. These materials were malathion, methoxychlor, and chlordane. (BS 1-3 (Rev.))

A new millivolt output meter was tested with the Gow-Mac thermal conductivity gas analyzer in an attempt to adapt this instrument to the analysis of HCN. Gas concentrations of HCN were successfully and accurately determined with this equipment, but it was too delicate for field use. Development of this unit marks a step forward in the analysis of HCN by thermal conductivity. However, more work needs to be done before the unit will be practical for general use. (BS 1-3 (Rev.))

New thermal conditioning equipment for hogsheads of cigarette tobacco was evaluated for insect control. It was found less effective against insects than the equipment generally used. (BS 1-3 (Rev.))

Tests with HCN have shown that the egg of the cigarette beetle is the most susceptible stage to this fumigant, followed by the adult, with the larval stage the most resistant. A study on the effect of exposure time and gas concentration on the mortality of all stages of the cigarette beetle has been completed. Time-concentration curves are now available for HCN, methyl bromide, and the acrylonitrile-carbon tetrachloride mixture against the cigarette beetle. (BS 1-69)

During a study to determine the behavior of gases in the fumigation of tobacco warehouses, it was found that heavier dosages of HCN than normally used in the past were the most practical. Three pounds of HCN per 1,000 cu. ft. provided a highly effective and economically feasible fumigation. (BS 1-70)



PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation.

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Tenhet, Joseph N. 1962. Control del escarabajo del cigarrillo en los tropicos AMS-439, 27 pages. (MQ 1)

## AREA 11 b. CUT FLOWERS AND ORNAMENTALS

Problem. The rapid increase in production of field grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and North Carolina, has raised many problems in marketing. Information on methods and materials for use in packaging, on the temperature requirements for storage and in transit, and on the prevention of decay are among the most urgent problems.

### USDA PROGRAM

The Department has a very limited program in marketing research on cut flowers and ornamentals, amounting to approximately 0.5 professional man-year.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State Experiment Stations did not report any work in 1961.

Industry activity included some development work on fiberboard containers. Estimated annual expenditures probably did not exceed one professional man-year.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

#### A. Transportation

1. Shipping Tests with Cut Flowers. Temperatures of cut flowers shipped by air from California to eastern and southeastern markets were mostly in the 50° to 70°F. range, but some summer flower temperatures were as high as 90° and some winter temperatures as low as 34°

Total period from packing to delivery ranged from 18 to 35 hours and averaged 25 hours in the 1961-62 season. In shipments to eastern markets (New York, N. Y. and Washington, D. C.) an average of about 32 percent of this time was spent before departure, 29 percent on the plane, and 39 percent between arrival at the eastern terminal and delivery to the wholesaler. In shipments to the Southeast (Orlando, Fla.) about 25 percent of the time from packing to delivery was spent before departure, 30 percent on the plane, 21 percent at transfer points, and 24 percent after arrival at the terminal.

Variations in transit temperatures and length of transit period were demonstrated to affect flower quality, particularly the opening of rose buds, decay of stocks, chrysanthemums, and asters, as well as

many less tangible quality factors. Transit temperatures were lower and more constant in a "bunker" type carton than in a conventional carton. In the bunker carton ice is placed at each end and space is provided for convection of cold air within the container. Transit temperatures also varied considerably among flowers shipped simultaneously by different routes. These results indicate that improved packaging and lower transit temperatures would reduce deterioration and extend the display life of cut flowers. (MQ 2-15)

## B. Post-harvest physiology

1. Chemical Retardation of Senescence in Cut Flowers. Garden stocks were sprayed with  $N^6$  benzyladenine just before or immediately after harvest. The flowers were stored for 5 days at 50°F. and subsequently for 3 days at 70°. The treated flowers were whiter and more compact and the leaves were greener than those of untreated plants. After the 70° holding period, the treated flowers were still in fair condition while untreated flowers were almost unsaleable. The results were similar when the plants were treated before or after harvest. Results were the same with either 25 or 50 ppm. No uptake of  $N^6$  benzyladenine occurred when ends of the stalks were immersed for 19 hours in a 25 or 50 ppm solution prior to the holding period.

Elongation of the inflorescence was reduced by about 20 percent when treated with a 25 ppm solution. Keeping the flowers in the light also reduced elongation.

The respiration rates of stock flowers treated with  $N^6$  benzyladenine was reduced about 20 percent; that of the whole plant was reduced about 15 percent. More mature flower buds respired faster than younger buds, ranging from 1.5 to 2.0  $\mu l$  O<sub>2</sub>/mg tissue (dry weight)/hr. (MQ 2-15)

## C. Post-harvest disease control

1. Mistletoe. Mistletoe twigs with attached leaves and berries were dipped in solutions (10 ppm) of 2,4-D and 2,4,5-T each of which were incorporated in: U-2069-2000 ppm, Captan 3 lb./100 gal., Dithane M22-2 qt./100 gal. and Hyamine 3500-2000 ppm. Triton B  $\frac{1}{2}$  pt./100 was used as a surfactant. After 13 days holding at 75° disease severity ratings indicated that U-2069, Dithane M 22 and Hyamine 3500 had each retarded mold development. Captan did not give effective mold control. Both 2,4-D and 2,4,5-T reduced berry and leaf abscission to approximately 1 percent. Mistletoe was heat treated in water at 130° for 5 minutes, packaged in vented bags and held for 10 days. Severe leaf scorch was evident after 3 days. Mold was observed on berries and leaves after 10 days. (MQ 2-15)



2. Stocks. Post-harvest sprays with the fungicide, Botran (2,6 dichloro 4-nitroanilin), reduced Botrytis decay of stocks from an average of 40 percent in check lots to 14 percent in the treated ones. Decay ratings were made after 5 days' storage at 50°F. and 95-100 percent relative humidity. (MQ 2-15)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Transportation

Harvey, J. M. and Uota, M. 1961. U. S. Department of Agriculture Studies Shipping Temperatures of Cut Flowers. California State Florists' Assoc. Magazine. (MQ 2-15)

Harvey, J. M. Uota, M., Segall, R. H., Lutz, J. M., Ceponis, M. J., and Johnson, H. B. 1962. Transit Temperatures of Cut Flowers Shipped from California. USDA AMS 459. (MQ 2-15)

Handling and Packaging

Gartner, J. B., Kushman, L. J., Haasis, F. A., and McIntyre, M. L. 1961. Handling and Storage of Holly. Proc. American Holly Society 30, pp. 5-8. (MQ 2-15)

## AREA 12 - VEGETABLES - MARKET QUALITY

Problem. Vegetables are subject to deterioration after harvest through normal and abnormal metabolic changes and by decay organisms. In addition they vary widely at harvest in the characters that determine market acceptance. Much additional information is needed on objective indices for harvest maturity, quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels. Research aimed at the reduction of wastage during marketing is needed on sources and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Consistently safe and effective transportation of the more perishable products can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market.

### USDA PROGRAM

The Department has a continuing program of applied and basic research relating to measurement, protection, and improvement of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Maryland; Fresno, California; Miami, Florida; Orlando, Florida; New York, N. Y.; Chicago, Illinois; and Harlingen, Texas and at the Michigan, Maryland, and North Carolina Agricultural Experiment Stations in cooperation with these stations. The work on lettuce precooling is conducted in cooperation with the Grower-Shipper Vegetable Association and the Western Growers Association who contribute financial support to the program.

A total of 18.7 Federal professional man-years is devoted to this program. Of this, 1.7 are devoted to objective measurement of quality, 3.6 to quality maintenance in handling and packaging, 2.8 to quality maintenance in storage, 5.4 to quality maintenance during transportation, 1.3 to post-harvest physiology, 3.4 to post-harvest disease control and 0.5 to program leadership.



Work terminated during the reporting period included: Provitamin A content as related to wilting and storage (BS 2-45), precooling and transit refrigeration of lettuce (BS 2-70), vacuum cooling of fruits, vegetables, etc. (BS 2-71), antibiotics for fresh vegetables (BS 2-74), ripening of mature green tomatoes (BS 2-85), phenolase and cytochrome oxidase during aging (BS 2-90), etc. as listed in project check list.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 25.4 professional man-years divided as follows: Objective measurement and evaluation of quality, 12.6; handling and packaging, 3.6; storage, 4.5; transportation, 0.5; post-harvest physiology, 4.0 and post-harvest disease control, 0.2. Much of the work on objective measurement and evaluation of quality is concerned with crops for processing. The storage work is concerned largely with physical and chemical changes that occur under various storage conditions.

Several agricultural supply companies do developmental work (estimated 3 professional man-years for vegetable crops) on materials for use as post-harvest fungicides, bactericides, or for wax or other coatings.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective measurement of quality

1. Dry Beans and Peas. A procedure for staining light colored legume seeds to determine seed coat damage was developed. This involves the use of indoxyl acetate in a simple dyeing procedure. It could be made applicable to seed inspection procedures. (MQ 3-18)

2. Tomatoes. Cooperative research with a tomato products manufacturer established satisfactory correlation between raw tomato juice color and processed product (ketchup) color as measured on the Tomato Colorimeter. The new inspection procedure was expanded to other locations on the basis of these findings and those of other commercial concerns who tested the new procedure and obtained similar correlations. In 1962 one of the largest manufacturers of tomato products arranged to buy all tomatoes received at a large Midwest plant paying growers on the basis of quality as determined by the new USDA inspection procedure.

"Non-usable" portions of grower's loads as defined by the new inspection procedure were often greatly in excess of the total processing plant trim waste. Average trim waste for loads sampled

in 1961 was 0.9 percent; the average "non-usable" portion was 6.0 percent. Further research is needed to narrow the difference in waste between inspector's graded sample and plant operation.

A new tomato prechopper for speeding preparation of the raw juice color sample was developed. Mounted just above the laboratory extractor and delivering directly into it, the prechopper will accept whole fruit regardless of size and macerate them for easy extraction into puree. (MQ 3-15)

3. Canned Southern Peas. The character grade in the standards for canned southern peas is based chiefly on maturity and tenderness. Methods for determining these factors in the processed product were evaluated. Alcohol insoluble solids increased from 17 to 27 percent with advancing maturity. Percent total solids and weight of peas also increased with maturity.

Shear-press measurement was indicative of the tenderness of the peas; however, tenderness could be altered to some extent by processing time and temperature. Mature peas tend to absorb brine and become mushy which increases drained weights and decreases the amount of free liquid, producing a product of undesirable eating quality.

Turbidimetric measurements were made but were inconclusive as a quality indicator for southern peas. (MQ 3-37)

4. Sweetpotatoes. Thirteen varieties and breeding lines were evaluated at Beltsville for processing quality. In 1961 Copperskin Goldrush ranked first, Centennial second, M97-4 third, B6716 fourth, and L4-89 fifth. In 1960 the ranking was as follows: Nugget, Centennial, Goldrush, M97-4, and HM288. L 3-64 was poorest both years.

The new skin color gradation chart developed with the cooperation of the Fruit and Vegetable Division was tested in 1961. Tests conducted in Mississippi and Maryland clearly showed that a workable tool is now available for evaluating the surface color of sweetpotato roots. It has been suggested to the industry and experiment stations for routine use. Plans are underway for its reproduction in quantity.

As a result of the 1961 studies recommendations have also been made for the objective evaluation of the flesh color of both the fresh and processed sweetpotato. Transformations of data to Hunter-Munsell color space indicated that a series of color chips in the region 2.5YR7/8 for fresh product and 7.5YR6/7 for processed product may be reproduced for use in quality control for both breeders and processors. (BS 3-49)

B. Quality maintenance in handling and packaging

1. Dry Beans. Study of samples of Michigan pea beans obtained from the two major production areas in Michigan indicated that field samples, samples at receiving elevators before cleaning, samples after cleaning and before being moved to storage, and initial storage samples were infested both with "field" fungi (dominantly Alternaria, Fusarium and Nigrospora) and storage fungi (Aspergillus and Penicillium). Cooperative work in a study of damage to pea beans in mechanical handling indicated that current handling procedures do not cause extensive breakage in beans with 14 to 18% moisture. Mechanical damage is severe at moisture contents below 14% and at temperatures below 32°F. (BS 2-160)
2. Shelled Lima Beans. Vacuum cooling reduced temperatures of prepackaged shelled lima beans from about 75°F. to 44° in 10 minutes and to 32° in 50 minutes. However, vacuum cooling can not be recommended because in two out of three tests, damage to the seed coat was noted. (BS 2-71)
3. Cauliflower. In two tests, freshly harvested Long Island-grown cauliflower was treated with a combination of N<sup>6</sup>-benzyladenine and 2,4-D and packed in polyethylene-lined and non-lined crates. After 3 weeks at 36°F., the treated heads in lined and in non-lined crates retained an average of 85 and 80% green leaves; while comparable figures for the non-treated heads were 58 and 52%, respectively. Cauliflower in lined crates showed less wilting but more decay than cauliflower packed in unlined crates. (MQ 2-61)
4. Tomatoes. A study was made to determine if overfilling of shipping containers causes bruising of mature green tomatoes. Bruising in tomatoes on arrival and after ripening at terminal markets was compared in containers filled to their rated capacity with that occurring in containers filled 2 to 3 pounds below or 2 to 3 pounds above their rated capacity.

In the test shipment from Florida to Washington, D. C., objectionable bruising was least in underfilled wirebound crates and greatest in overfilled ones. In tests from Florida to New York, there were no differences attributable to amount of fill in the three types of packages used. Likewise in the test from Texas to Chicago net weight had no effect on degree of bruising in wirebound crates.

Most bruising occurred in tomatoes that were ripe or pink when unloaded.

Studies were conducted to determine the handling procedures prior to shipment that influence internal bruising of Florida green



tomatoes. Little internal bruising was attributable to field and packinghouse handling. The riper tomatoes were more subject to internal bruising than the mature-green or breaking fruit.

Harvesting and handling mature-green tomatoes from the field to the packinghouse, including the placing of fruit in the picking bucket, dumping them into field boxes, and trucking the field boxes to the packinghouse, caused a negligible but cumulative increase in serious internal bruising, totaling about 0.3 percent by the time the tomatoes reached the packinghouse.

After dumping and washing the tomatoes at the packinghouse, the cumulative internal bruising injury increased to about 1 percent. Grading for externally damaged fruit removed some fruit with internal bruising, but internal bruising increased during the final packing procedures to an average of about 1 percent in the final package.

Apparently most of the internal bruising of tomatoes upon arrival at terminal markets is caused by constant pressure, shock and vibration received during transit. (MQ 2-36)

Additional studies demonstrated the hidden and cumulative nature of bruising injury, and also an increase in bruising with each additional handling operation incident to ripening and repacking. A substantial reduction in bruising was obtained, in tests, through careful handling, and through the use of foam-rubber pads.

Tomatoes are bruised from fixed pressure, from impacts, and from strong shock vibrations. Fruits under fixed pressure for 5 days or longer were permanently pressed out of shape and damaged internally. In studies simulating commercial harvesting, sorting, and packing conditions, it was found that bruising was positively correlated with the number of drops, with the height of the drop, and with the ripeness of the fruit. (MQ 2-23)

5. Lettuce. When N<sup>6</sup>-benzyladenine was applied to lettuce, the outer leaves remained green longer. Segments from lettuce leaves sprayed before harvest with 10 ppm N<sup>6</sup>-benzyladenine had a respiration rate that was about 25 percent higher than unsprayed segments. When lettuce was sprayed with 0, 5, 10, and 20 ppm about 24 hours after harvest, the respiration rate in lettuce treated with 5 ppm was unchanged but the rate increased in proportion to the concentration in lettuce sprayed with concentrations above 5 ppm. The material is not translocated and only the outer leaves of the head are affected. Since these leaves are usually trimmed before sale, the value of this treatment on untrimmed lettuce is questionable. (BS 2-70)

6. Onions. During the 1960-61 season two lots of onions were examined and placed in common storage at Orange County, New York. They were graded and packaged into 3-pound polyethylene bags during March and April and followed through the marketing channels. Bruising averaged 3 percent after grading and packaging. By the time the onions were delivered to the retail stores, bruising had increased to 16 percent. However, most of the bruising was classed as slight and not considered of commercial significance. Very little decay (average 1.4 percent) was found during retail or after holding for 7 days at 70°F. Sprouting was the principal defect found during marketing. (MQ 2-38)

7. Packaging of Plants. Adoption of the bare-root method of shipping tomato plants from Georgia to New Jersey and Canada in polyethylene-lined crates is proceeding on a semi-commercial scale. In cooperation with a commercial processor many refrigerated trucks with part loads of 100 to 200 poly-packed crates were shipped in May and June to determine grower acceptance. Most plants arrived in excellent condition. Some growers are skeptical of the condensation of moisture within the liners. Ventilation was improved by leaving the film liner partly open at the top during shipment and opening it wider after arrival. Perforations were added to the bottom of the liners to allow soaking of plants if necessary before planting. There were some complaints about crooked plants when bundles slipped down in the crates. This objection occurred most often in slack-pack crates. (BS 2-97)

8. Asparagus Plants. First year yields were obtained on trimmed and non-trimmed asparagus plants which were stored at 32°F. before planting. Yields from plants with roots trimmed to 8 inches were the same as those from plants with non-trimmed roots. Yields from plants with roots cut to 4 inches from the crown were less than those from plants with non-trimmed roots. There was no difference in yield from plants stored in burlap or polyethylene bags. By trimming roots to 8 inches before storage, nurserymen could save 15 percent in storage space, reduce shipping costs, and provide growers with plants easier to handle. (BS 2-137)

9. Rhubarb. At the request of a commercial packer, preliminary tests were made using Maryland-grown rhubarb to determine shelf life and types of deterioration of prepackaged cut rhubarb. Rhubarb cut into 1-inch pieces and packaged in perforated polyethylene 10-oz. bags held up well for 2 weeks at 32°F., 1 week at 40° and 1 day at 50° or 60°. Shelf life at 70° was less than 1 day. Serious splitting and curling of outer layers, discoloration of cut surfaces and soft rot limited shelf life.

Rhubarb moderately wilted during 2 weeks at 32°F. and 85% relative humidity and then cut for packaging held up better for 1 day at

70° than did turgid rhubarb. Various solutions tried to prevent splitting, curling or reduce discoloration of cut surfaces were not effective. (MQ 2-61)

### C. Quality maintenance in storage

1. Onions. Onions held 3 weeks in common storage (daily temperature maxima between 77° and 95°F.) before transfer to cold storage (32°) had more physiological breakdown after 4 to 7 months' storage than onions placed in cold storage immediately after harvest. The percentages of affected bulbs in lots cooled immediately and after delay were, respectively, 0 and 4.5% after 4 months, 1 and 7% after 5 months, 12 and 28% after 6 months, and 29 and 39% after 7 months. Large bulbs were more affected than medium or small-sized ones. Onions grown on mineral soil or peat soil were about equally susceptible to this breakdown. Shading of the bulbs during growth in peat soil had no effect on the incidence of the disorder.

Higher than normal amounts of CO<sub>2</sub> in the storage atmosphere (at 32°F.) caused an injury indistinguishable from physiological breakdown. After 5 months, 4.2% of the bulbs held in normal air were affected, whereas in the following atmospheres: 5% CO<sub>2</sub> and 5% O<sub>2</sub>; 5% CO<sub>2</sub> and 15% O<sub>2</sub>; and 10% CO<sub>2</sub> and 15% O<sub>2</sub> breakdown developed to the extent of 11.1, 8.6, and 93.1%, respectively.

2. Sweetpotatoes. Tests in North Carolina with CIPC, applied as a dip or aerosol, effectively controlled sprouting of sweetpotatoes at ambient storage temperatures (55 to 65°F.) and at elevated temperatures (70° to 80°F.). (BS 2-130)

3. Ripening and Storage of Tomatoes. Tests were initiated to develop standards for predetermining ripening rate of tomatoes. "Turning" and "pink" tomatoes, sorted into 6 classes with the Agtron Model F photoelectric instrument, were ripened at 58°, 65°, and 70°F. Tomatoes having similar Agtron readings when just breaking color ripened uniformly to full color.

Mature-green tomatoes breaking color in 1, 2-3, or 4-10 days after arrival at market completed ripening at approximately the same rate (from the time of color break), and reached the same intensity of color when ripe.

Pre-storage color standards were determined objectively for tomatoes to be ripened at 58°, 65°, or 70°F. These will insure uniformly ripened fruit in 4 to 12 days.

Fully-ripened tomatoes lost color and firmness when stored for prolonged periods at 33°-35°F. Such tomatoes remained edible for 3-4 weeks, however, when used directly from cold storage. (BS 00-1)



4. Detection and Description of Freezing Injury of Fresh Vegetables.

Symptoms of freezing injury were studied in 14 vegetables. The most common symptom of freezing in green onions, radishes, lima beans, green beans, peppers, cucumbers, squash, bulb onions and turnips was watersoaking. Usually it appeared first on the outer surface of the vegetable as small, more or less circular, abnormally darkened spots. As the freezing progressed the spots gradually coalesced until the entire surface was affected. Internally, frozen areas were generally translucent in appearance rather than opaque. In some instances, particularly with lightly or moderately frozen green beans and turnips, the watersoaking disappeared during thawing.

Internal or external darkening was found to be a symptom of freezing injury in sweet potatoes, carrots, and beets.

Internal or external cracking characterized freezing injury in beets and carrots. Caused by the formation of ice crystals, the small cracks tended to close as the ice melted but, even after complete thawing, the cracks could easily be observed with the use of a microscope.

Pitting was commonly found in peppers, eggplants and radishes after freezing and thawing.

Flabbiness or shrinking due to substantial loss of moisture was observed in parsnips, carrots, peppers, cucumbers and green beans that has been frozen and thawed.

In general, thawing at 40°F. resulted in less damage to the product than thawing at 70°. (MQ 2-29)

D. Quality maintenance during transportation

1. Asparagus. Two insulated master containers, each holding 200 pounds of precooled, prepackaged early asparagus, were shipped from Stockton, California to New York via jet air liner. Transit temperatures were between 50 and 64°F. principally because of warming during delays after hydrocooling. Arrival condition was satisfactory, in spite of the high temperatures, because of the short transit period involved. The atmospheres within the two relatively tight containers were modified only slightly during shipment.

To determine the effect of modified atmospheres, during transit periods asparagus spears were held at 36°, 41°, and 50°F. in 10, 20, 30, or 50% CO<sub>2</sub> and 10% or more O<sub>2</sub> for 24 hours, and then in air for 6 days at the same temperatures. The CO<sub>2</sub> treatments were effective in reducing soft rot of the butts to a maximum of 6% with

10% CO<sub>2</sub>, and to negligible amounts at 30% or more CO<sub>2</sub> as compared with 16, 31 and 37% at 36°, 41° and 50°, respectively in untreated spears. However, other injury occurred at the higher concentrations of CO<sub>2</sub>. At 20% CO<sub>2</sub> or below no injury was evident. Benefits from a short exposure to CO<sub>2</sub> might be particularly useful in air shipments. (MQ 2-13)

2. Dry Beans. Details of a study on the effect of transit conditions during shipment from the Great Lakes' ports via the St. Lawrence Seaway to Western Europe have been published. One shipment was accompanied and two additional shipments were instrumented to obtain temperature and moisture information at points throughout the ship's hold. Quality measurements were made at origin and at destination. From this study changes in grade and quality of burlap bags and in loading and unloading procedures have been recommended to reduce the excessive physical damage now occurring. The careful use of ship aeration equipment to ventilate holds was recommended so that moisture content of the cargo does not increase during passage from the relatively cool to the warm moist climate encountered in the voyage. (MQ 2-30)

A shipping test program in cooperation with the School Lunch Program (ASCS) and the Multiwall Paper Shipping Sack Manufacturers' Association has been initiated to test the suitability of multiwall kraft 100 pound bags vs. burlap bags now standard for such shipments. Tests to date indicate that the kraft bags are satisfactory for use. (MQ 2-30)

A contract has been made with Agricultural Specialities Company, Hyattsville, Md. to construct a prototype, portable, battery-operated, multipoint-temperature recording device which will operate unattended for periods of up to two weeks. It is designed primarily for use in transportation tests. (MQ 2-30)

3. Brussels Sprouts. The keeping quality of vacuum cooled and hydrocooled prepackaged and bulk Brussels sprouts was compared during simulated transit and marketing periods. Vacuum cooling reduced the temperature of the sprouts to 40°F. and could be done after packaging. Hydrocooling had to be done before packaging because the package prevented adequate contact with the water.

Salability of all lots of sprouts was rated "good" or better after 8 days at 34°F., but the lots that were vacuum cooled without pre-wetting were slightly more wilted than those that were wet before vacuum cooling, or those that were hydrocooled. Top ice helped maintain freshness of the sprouts, especially in the non-packaged lots.

All lots deteriorated somewhat during the additional 2-day period at 70°F. However, the hydrocooled lots retained the freshest appearance and the lots vacuum cooled dry were the most wilted. (BS 2-71)

4. Cantaloups. Western-grown cantaloups are usually shipped under Standard Refrigeration with full-bunker icing. This refrigeration service was compared to half-stage Standard Refrigeration and a modified full-bunker service using 1 re-icing for cars shipped to Chicago and 2 re-icings for cars shipped to New York. The results showed that Standard Refrigeration, full-bunker icing was not needed. Less costly services provided adequate refrigeration for precooled cantaloups. Half-stage Standard Refrigeration or modified full-bunker refrigeration with 2 re-icings would save the industry \$35.19 and \$19.77 per car, respectively, over the conventional service for cantaloups shipped from California to New York. Half-stage Standard Refrigeration would save \$29.88 and the modified service with 1 re-icing would save \$36.50 per car for shipments to Chicago.

Precooling cantaloups by conventional methods is impractical with some of the new containers for melons. The half-cooling times for cantaloups were determined for each of the methods commonly used for melons in wooden crates. Knowing the half-cooling time, a shipper can calculate the time required to cool cantaloups from any initial temperature to any desired temperature. The half-cooling time for cantaloups precooled with top ice and fans in the car was 3 hours; that for melons cooled in a tunnel by forced air was 1-1/4 hours; and that for hydrocooled melons was 1/3 hour. Cooling by any of these methods is fast enough to be practical for commercial handling of crate-packed cantaloups. The half-cooling time for cantaloups packed in cartons and precooled in the car by forced air varied from 2 to 12 hours, depending on the method of loading and the position in the load. Cooling carton-packed melons by this method was usually too slow to be practical for commercial operations. (MQ 2-14)

The market quality of hydrocooled and air-cooled melons was about equal after a simulated transit period at low temperature and a marketing period at room temperature. Cracking of melons was negligible in a commercial hydrocooler. Cantaloups did not absorb water during hydrocooling. However, weight-loss was slightly greater in room-cooled than in hydrocooled melons during subsequent holding.

Cantaloups that were initially above 90°F., generally deteriorated more rapidly than those that were initially about 70°, even though both lots were cooled to and held at the same temperature.

Sodium ortho-phenylphenate (1000 ppm) or calcium hypochlorite (200 ppm), added to the cooling water, reduced surface mold materially. (MQ 2-14)

#### 5. Lettuce.

Vacuum Cooling. Temperature reduction in carton-packed lettuce was improved by lowering the pressure in the tank below the 4.6 mm Hg. level normally used. Evacuation to pressures as low as 3.8 mm Hg.



was safe when the time and pressure were properly controlled. Final lettuce temperatures near 32°F. are necessary to maintain quality. For the precise control of pressure in the chamber to prevent freezing at this level, a dial-type high vacuum gage was more reliable than the wet-bulb and "pulp" thermometers now used for control purposes. Thermocouples to measure the temperature of the cooling coils in tanks employing mechanical vacuum pumps were also helpful in achieving better control of cooling. Ammonia pressure gages on the suction line from the coils did not indicate the true temperature of the cooling coils, the temperature at which water vapor from the lettuce was condensed. Lettuce cooling was similar throughout the length of the vacuum tanks tested. However, lettuce cooled slightly slower in cartons in the middle layer of solid loads than in more exposed locations. These results suggest the desirability of more open placement of cartons on the pallets or in rail cars and truck trailers to be vacuum cooled.

Post-Harvest Handling. Delays between harvest and vacuum cooling are considered in new grades for lettuce. In one test in California a delay of 9-1/2 hours at about 70°F. caused lettuce to have about twice as much decay as delays of 2 or 5 hours. The differences due to delay were small when lettuce was held at 35° instead of 41°. In two other tests under similar conditions no such differences occurred.

Lettuce cooled 6 hours after harvest showed significantly more pink rib than lettuce cooled after only 1-1/2 hours.

Lettuce vacuum cooled to 38°F. and held 8 days at 38° (frequent commercial practice) had more russet spotting and decay than lettuce either cooled to 34° and held at 34° (desired practice) or packed in ice and held under top ice. After an additional 4 days at 50° twice as many heads with decay occurred in lettuce previously held at 38° or packed in ice than lettuce held at 34°. (MQ 2-58)  
(See also Post-Harvest Physiology E-1)

6. Fresh Peas. In cooperation with T.&F.R.D. tests were made to determine transit temperatures and breakage of bushel tub baskets when fresh California peas are iced with various amounts of top-ice. Peas are usually top-iced at shipping point with ice crushed from 80 blocks (24,000 pounds). This amount was compared to initial top-ice from 40 to 55 blocks plus half-stage bunker ice at the first regular icing station and one retop-icing in transit. All cars were loaded in the conventional manner, 5 high x 6 wide with baskets alternately inverted crosswise and lengthwise through the car. The baskets were loaded with tops to tops and bottoms to bottoms. Previous tests showed that modifications to secure a more solid load reduced rate of cooling.

Commodity temperatures were essentially the same with either icing practice, averaging about 37°F. Container damage data have not yet been evaluated. In most cars very little (0-2 inches) top-ice remained on the load near the bunker fans at destination. The thickest layer of top-ice was generally near the doorway. (MQ 2-21)

7. "Vine Ripened" Tomatoes. Tests were made at Beltsville on the effect of cooling and holding temperatures on ripening of tomatoes harvested when showing 10 to 15, 20 to 30, and 30 to 45 percent red color. Following 4-day holding periods at 60°, 55°, and 50°F. the tomatoes were ripened at 70° and the quality of red color was determined. Tomatoes showing 30 to 45 percent color at harvest needed to be cooled quickly and transported at about 50° to control ripening. Fruits with less than 30 percent color benefited by moderate temperatures of 55° and 60° during the 4-day simulated transit period. For example, tomatoes harvested at 10 to 15 percent color and held at 60° for 4 days were near the stage of ripeness of those harvested at 30 to 45 percent color and held 4 days at 50°. The tomatoes harvested at all three stages of maturity ripened satisfactorily at 70°. (MQ 2-23)

#### E. Post-harvest physiology

1. Russet Spotting in Head Lettuce. Lettuce harvested in California 9 to 14 days after air temperatures in the field exceeded 86°F. for 2 or more consecutive days developed more russetting after holding at 37° or 41° than lettuce not so exposed in the field. These observations suggest that lettuce which is known to be especially susceptible to russet spotting because of exposure to high field temperatures should be precooled to as near 32° as possible since this temperature is known to retard spotting as compared with 38° to 40°.

A delay of 9-1/2 hours at temperatures of 70°F. or below between harvest and vacuum cooling did not increase the incidence of russet spotting when lettuce temperatures were about 70°F. at harvest. (MQ 2-11)

2. Ripening of Mature Green Tomatoes. In tests at Beltsville in 1960-61, turning-stage tomatoes stored in 1% oxygen and 0 to 5% CO<sub>2</sub> developed some off-flavors after 4 weeks' storage at 55°F. These largely disappeared after an additional 6 days at 65° in normal air. However, uneven ripening, softening and breakdown were excessive.

A combination of 3% O<sub>2</sub> and 5% CO<sub>2</sub> at 55°F. did not produce off-flavors or excessive softening and gave some promise for delaying ripening and prolonging storage of turning-stage tomatoes. A slight amount of uneven ripening was noted with this combination.

Ethylene production of tomato tissues from mature-green and firm-ripe fruit was increased many fold when the tissues were cut into 4 mm sections. Maximum ethylene production was obtained in 30% oxygen and at a temperature of approximately 90°F. as the tissue turned to a full red color. (BS 2-85)

3. Liquid Nitrogen as a Refrigerant. The refrigerator car lines and the producers of liquid nitrogen requested information on the biological effects that high nitrogen concentrations might produce in fresh commodities during transit with liquid nitrogen as a refrigerant.

In preliminary tests in California simulating transit conditions, no significant difference in wilting or weight-loss was found between lettuce held under liquid nitrogen refrigeration or that stored in a cold room at about the same temperature. Liquid nitrogen reduced the oxygen level from a normal 21 percent to a range of from 5.4 to 8.5 percent. No injury from reduction of oxygen to this level was found when the lettuce was examined immediately after storage, or after a simulated marketing period. Freezing occurred in lettuce in the top layers of the load and in other positions exposed to the direct stream of nitrogen. Shortening the release cycle, re-positioning the thermostat, or improving the distribution of the gas, may eliminate freezing. (BS 2-70)

Tests were initiated in Texas to determine the tolerance of fresh commodities to low oxygen concentrations, such as might occur with liquid nitrogen refrigeration. Carrots and tomatoes were stored at recommended transit temperatures up to 10 days in nitrogen with oxygen concentrations of 2-1/2% without undesirable effects. (MQ 2-71 pending)

Tests were also conducted at Beltsville comparing 0, 1, and 20 percent oxygen with nitrogen making up the balance of the atmosphere. Mature-green tomatoes held at 60°F. for 7 days or longer in 0 percent oxygen were injured, failed to ripen properly and decayed rapidly when removed to normal air. When held in an atmosphere of nitrogen with 1 percent oxygen for periods up to 10 days, tomatoes ripened normally in air but more slowly than fruits which had been continuously in unmodified air. No abnormal flavors were detected in tomatoes held in pure nitrogen for 4 or 7 days at 60°, or in tomatoes held in nitrogen with 1 percent oxygen for 4, 7 or 10 days followed by ripening in normal air. Butts of lettuce heads discolored less, and leaf color remained greener in atmospheres of 1 and 0 percent oxygen than in normal air. Flavor remained normal in lettuce held at 33°F. for 4, 7 or 10 days in nitrogen with 1 or 0 percent oxygen. Russet spotting was almost completely inhibited in pure nitrogen and was reduced in 1 percent oxygen. The differences remained even after holding all heads for 4 days in normal air.



These results indicate that the vegetables were more tolerant to 0 or 1% oxygen, with the balance nitrogen, than was expected and that it was unlikely that liquid nitrogen refrigeration would be harmful to produce. (MQ 2-71 pending)

4. Respiration Studies. Respiration rates of topped carrots were 20 percent lower than those of carrots with tops but were 30 percent higher than previously reported rates. Fresh sweet corn with husks intact respired at a 5-10 percent lower rate than those with husks removed. Green onions, as shipped with roots and tops, produced a calculated 14,000 B.t.u. per ton per day at 40°F., one of the highest rates for any vegetable. Green onions with uninjured tops respired at a rate about 6 percent lower than those with some tops crushed. Broccoli produced 80,000 B.t.u. at 75°F., 38,000 at 60°, 18,000 at 50°, 7,600 at 40°, and 4,400 at 34°. Watermelons, both large and small, were studied, and the respiration rates of the two sizes were found to be similar; they averaged 9,800 B.t.u. at 90°, 4,700 at 70°, 1,600 at 50°, and 800 at 40°. Green sweet peppers produced 9,650 B.t.u. at 70°, 5,000 at 60°, and 3,200 at 50°. (BS 2-141)

5. Cause and Prevention of Tomato Waxy Blister. Tests were continued at Harlingen, Texas to determine the cause and possible control of tomato fruit tumor (waxy blister). Potted tomato plants of the Pearson variety were exposed to prevailing outside air temperatures, the fruit picked, some bruised, and all held at 78°F. for possible development of tumors. Degree hours (night temperatures below 60°F.) for the 7-day period before each picking date for the five test lots in which the fruits developed no tumors ranged from 0 to 121. The five test lots having the most fruits affected with tumors were exposed to 232 to 836 degree hours below 60° during the 7-day period. Tumor formation is not induced by nocturnal temperatures below 60° if incurred 6 and 7 days before harvest. The results confirm those obtained in previous years in that low temperatures less than 6 days before picking appear necessary for subsequent development of tumors at ripening temperatures. (MQ 2-54)

6. Ethylene, Origin and Role. Ethylene and other volatile emanations from plant tissues play an important role in the ripening of some vegetables. An enzymatic system has been isolated from plant tissue which in the presence of thiomalic or thioglycolic acid and linolenic acid will produce ethane and minute quantities of ethylene. The interrelationship of the production of these two gases is being studied. Ethylene oxide has also been identified as a volatile product of ripening fruit and has been found to have a temporary inhibiting effect on the ripening of tomatoes. A delay of 5 to 21 days, depending on the degree of ripeness when treated, followed by normal ripening has been obtained. Wounding stimulates

ethylene production by tomato tissue. No chemical treatment has been found that is highly specific for the control of the ethylene system. (Pioneering Laboratory)

7. Physiological Studies on Sweetpotatoes. Further studies with mitochondria from cells of sweetpotatoes indicate that mitochondria can be separated into smaller particles by sonic irradiation and still retain some activities characteristic of the mitochondria. Significant levels of DPNH-cytochrome c reductase and cytochrome c oxidase activity were present. These and other tests indicate mitochondria are made up of a number of units, each containing an electron transport chain. Mitochondria isolated from frozen sweetpotatoes were devoid of any dehydrogenase activity whereas frozen turnip and parsnip tissues exhibited activities equivalent to non-frozen tissues. Attempts will be made to determine if dehydrogenase activity is related to chilling injury. A recently completed study on ATP-ase activity failed to show significant difference between chilled and non-chilled roots. (Pioneering Laboratory)

#### F. Post-harvest disease control

1. Artichokes. Precooling and storage tests were conducted in California to compare the quality of buds that were room cooled or hydrocooled a few hours after harvest with buds that were room cooled 48 hours after harvest (usual practice in most packing sheds). Subsequent to precooling, the artichokes were held under simulated transit and marketing conditions. Artichokes room cooled 48 hours after harvest had about 2 to 4 times as much decay as those precooled within a few hours of harvest. Buds room cooled immediately after harvest were slightly more wilted after holding than those hydrocooled.

The addition of a fungicide (3,000 ppm dehydroacetic acid) to the cooling water did not result in appreciable decay reduction.

The type of container (crate, crate with perforated polyethylene liner, waxed carton) had no effect on quality. However, the use of top-ice during the holding period minimized wilting. (MQ 2-2)

2. Carrots. Several lots of prepackaged carrots from commercial shipments to Chicago were observed to be affected with a disease tentatively identified as Geotrichum sp. The organism attacks tips of roots causing a progressive, soft, slimy, sour decay. Studies show the fungus to be favored by high temperatures and high relative humidity. Infection occurs only through wounds. Optimum growth of organism in vitro was 75-90°F. (MQ 2-64)

3. Lima Beans. Lima beans from several eastern states were obtained on the New York market. They were shelled mechanically, treated with 100 ppm of chlortetracycline hydrochloride, and packaged in perforated polyethylene bags. These beans were in marketable condition for 4-5 days at 47° and about twice as long at 37°F. The shelf-life of the non-treated lots was about 1 day less at each temperature. (BS 2-74)
4. Cabbage. Tests were conducted in New York City with fresh and stored cabbage from New York and fresh cabbage from Florida. Black leaf speck was always associated with holding at low temperatures (34-40°F.). However, the incidence of specking varied markedly between heads within a single variety. Storage of cabbage in sealed or open containers or treatment with 9,000 ppm ethylene had no effect on specking. Black leaf speck was not associated with either cauliflower mosaic or turnip mosaic viruses. (MQ 2-43)
5. Chinese Cabbage. In studies in Florida, decay of Chinese cabbage was found to be caused by a bacterium, Erwinia, sp. The bacterium causes primarily a stem decay at temperatures of 50°F. and higher. Commercial hydrocooling does not lower the temperature enough to inhibit decay during transit. Commercial vacuum cooling does reduce the temperature sufficiently so that little decay would develop if low transit temperatures were maintained. (MQ 2-47)
6. Celery. It was demonstrated that fungi cause butt discoloration of packaged celery hearts. Two fungi, Cephalosporium sp. and Fusarium sp., cause the discoloration, the former at a temperature as low as 40°F. and the latter as low as 32°F. These fungi have been found associated with dirt adhering to the harvested celery. (MQ 2-47)
7. Cucumbers. In a study of the modes of infection of cucumbers by the black rot organism, germinating spores initiated infection directly without the presence of surface wounds. (MQ 2-64)
8. Escarole and Endive. The breakdown of escarole and endive is primarily physiological followed by bacteria and fungi causing the decay symptoms. Dipping endive and escarole in a solution of 10 ppm N<sup>6</sup> benzyladenine delayed the physiological breakdown and secondary decay, thereby increasing the shelf life two days. (MQ 2-47)
9. Parsnips. Infection studies with Itersonilia perplexans were continued at Chicago. Inoculated parsnips were placed in polyethylene bags and incubated at 32°, 45°, 50°, 55°, 65°, 70°, and 90°F., for 14 weeks. No decay developed at 32° or 90°F. Moderate decay occurred at 45°. Maximum decay was at 55°. In vitro test paralleled infection tests in lower temperature ranges. There was no growth at 32° or 90°. Maximum fungus growth was at 65°F. (MQ 2-64)



10. Peppers. Washing, waxing, and chlorine treatments are commonly used in the commercial handling of green and red bell peppers shipped from Texas. An extensive test was made with several chemical and antibiotic dips to evaluate their effectiveness for control of bacterial soft rot in inoculated green peppers. After holding for 7 days at 46°F. and 11 days at 60°, decay control in the treated lots ranged from 17 to 87% better than the untreated checks. The best three treatments in order of effectiveness were: (1) Phytomycin (100 ppm); (2) Agri-mycin (200 ppm); and (3) Sodium orthophenylphenate plus hexamine (2%) followed by water rinse. A dip containing chlorine (250 ppm), an ingredient commonly used in commercial treatments, was one of the least effective. The waxed non-inoculated peppers developed five times as much bacterial soft rot as non-waxed ones. These and earlier tests have indicated that washing, waxing, and possibly hydrocooling increased the incidence of bacterial soft rot in Texas peppers. (Line Project pending)

Studies on gray mold were begun in Chicago to determine the various factors necessary for conidial germination in vitro and on the host. Studies indicated adequate spore germination in water but is greatly increased by various nutrients. Experiments to date indicate infection occurs only through wounds. (MQ 2-52)

11. Radishes. The causal organism of radish black spot was identified as a variety of Xanthomonas vesicatoria. The bacterium invades the growing radish through insect wounds, or injuries incurred during harvesting, washing, and grading. Control of black spot was obtained by adding 40-60 ppm chlorine to the wash water. Control was not obtained by treating radishes with chlorine, dehydroacetic acid, potassium sorbate, or other compounds after washing. Evidence was obtained that the causal bacterium is present in the muck soil and is introduced into the packinghouse on infected radishes or soil clinging to the radishes.

In an effort to reduce this source of bacterial inoculum, the soil in which the radishes were grown was treated with many chemicals in cooperation with the Florida Experiment Station. Three of the treatments were effective in reducing the amount of black spot lesions on radishes at harvest. They were: Vapam 150 gal./acre; Vapam 100 gal./acre + Agrokote 600 gal./acre; and Mylone 300 lbs./acre + Agrokote 600 gal./acre. They were equally effective when applied one month before seeding. (MQ 2-64)

12. Sweetpotatoes. Several commercial packinghouses in North Carolina and Georgia installed the SOPP (sodium o-phenylphenate tetrahydrate) treatment, developed during the course of this project, for the control of soft rot during marketing. A simplified test for determining concentration was developed and successfully used by packinghouse operators. In four test shipments of cured roots from

eastern North Carolina to New York, N. Y., or Chicago, Illinois, commercially treated roots developed 66 to 75 percent less decay than comparable non-treated roots after 1 week in the market. The average reduction in decay was 7.5 pounds per 100 pounds shipped or about 37 bushels per 500 bushel load. At \$5 a bushel this amounts to \$185 per load.

Much of the decay in bushel baskets occurs just below the lid as a result of abrasion. Decay in the top of the basket was reduced about 33% by treating the lid with SOPP and about 50% by using excelsior lid cushions.

Additional screening tests in North Carolina verified that Botran (2,6-dichloro-4-nitroaniline) effectively controlled soft rot but is relatively ineffective against black rot. Warm water treatments (100 to 140°F. for 1 to 7 minutes) reduced soft rot but caused surface discolorations on some varieties at effective combinations of temperature and time. The best control of soft rot was obtained with a combination of heat and SOPP.

The effect of three treatments on the keeping quality of Jersey Orange sweetpotatoes in bulk  $\frac{1}{2}$ -bu. cartons, in 3-pound polyethylene mesh (Vexar) bags, and in perforated polyethylene film bags was determined at Beltsville. The test was conducted in March after the roots had been in storage several months. Rhizopus decay was significantly reduced in the consumer bags by each of the treatments: a 30-second dip in SOPP, a 30-second dip in Botran (2,6-dichloro-4-nitroaniline), and a 3-minute dip in 120°F. water. None of the treatments injured the sweetpotatoes. Perforated polyethylene bags (32  $\frac{1}{4}$ -inch holes) reduced weight loss by about 1/3 as compared to mesh bags or corrugated cartons.

Now that an effective method for control of decay has been developed and approved for use, it is possible to prepackage sweetpotatoes. This has been impractical heretofore because of decay. (BS 2-130)

Studies were conducted at Beltsville on enzymes causing rotting of sweetpotatoes. The juice squeezed from Rhizopus-rotted sweetpotatoes contained readily detectable quantities of polygalacturonase, macerating enzyme, carboxymethylcellulase, and natural cellulase. These results agreed with those obtained in studies of filtrates from Rhizopus sp. grown on a special pectin-polypectate mineral salts medium. The cellulolytic enzyme properties of Rhizopus have not been reported previously although carboxymethylcellulase has been detected in Rhizopus-rotted sweetpotatoes. (MQ 2-60)

13. Tomatoes. Rhizopus stolonifer, Alternaria tenuis, Colletotrichum phomoides, and Phomopsis spp. were isolated from tomatoes and their pectic enzyme production in artificial media

studied. A. tenuis and R. stolonifer were roughly comparable in production of polygalacturonase and macerating enzyme, C. phomoides produced a lesser amount of polygalacturonase and only a trace of macerating enzyme, and the species of Phomopsis produced little or none of either type of enzyme. No evidence of pectic enzyme inhibitors was found in tomato preparations. (MQ 2-60)

14. Watermelons. Watermelons inoculated with Mycosphaerella melonis developed less than 1% decay at 45°F. Decay developed progressively faster as the temperature was raised to 75° and decreased between 75° and 85°. Growth in vitro was slight after 7 days at 45°; optimum growth occurred at 75° and decreased at 85°. Melons inoculated with Pellicularia rolfsii showed slight rind decay at 55°. Extensive decay occurred in melons held 14 days at 90°. In vitro studies showed optimum growth temperature for P. rolfsii was between 86° and 95°; minimum was 46.4° and maximum 104°.

In 1961, anthracnose (Colletotrichum lagenarium), black rot (M. melonis), Phytophthora capsici and stem-end rot (Diplodia natalensis) were the principal watermelon diseases observed on the Chicago market. Anthracnose occurred mainly on the Charleston Gray variety from Georgia. Black rot was observed mainly on Black Diamond from Arkansas and Georgia. Phytophthora rot was seen only on the variety Peacock from Mexico. Losses from this disease in some carlots averaged 6%. Diplodia stem-end rot was observed more frequently in 1961 than in 1960. Percentages of this decay in various lots of melons ranged from 0.5 to 27.3. (MQ 2-59)

15. Mode of Action of Bacterial Soft Rot of Vegetables. In additional studies at New York of the mechanism of pathogenesis by the vegetable soft rot bacterium, Erwinia carotovora, leaves of witloof chicory were inoculated with a virulent, wild-type strain and with an attenuated mutant strain induced by ultraviolet light irradiation. After 24 hours' incubation at about 70°F. the leaves inoculated with the virulent strain contained an average of  $158.7 \times 10^6$ , viable bacterial cells per gram of leaf tissue. Leaves inoculated with the attenuated strain contained  $23.1 \times 10^6$  cells. At the end of 24 hours' incubation the soft-rot lesions caused by the virulent strain averaged about 30 x 10 mm. in size, while lesions caused by the attenuated strain were about 10 x 2 mm. The virulence of the two strains was correlated with the rate of their growth in vivo.

In laboratory studies of two vegetable soft rot bacteria, cultures of E. carotovora were observed to become somewhat attenuated during prolonged culture but rarely to become avirulent, whereas cultures of Pseudomonas marginalis became attenuated more rapidly and often became avirulent. Following ultraviolet light irradiation of suspensions of P. marginalis, 17 surviving colonies were tested for



virulence. Six subcultures remained fully virulent, none were attenuated, and 11 were avirulent. In tests with suspensions of E. carotovora, 136 colonies surviving irradiation were tested for virulence: 121 subcultures remained virulent, 15 were attenuated, and none were avirulent. The results of irradiation indicate that the rate of mutation for loss of virulence is greater for P. marginalis than for E. carotovora. (MQ 2-3)

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## AREA NO. 13 INSECT CONTROL IN MARKETING CHANNELS -- CROSS COMMODITY

Problem. Numerous problems associated with market quality affect several commodities similarly; chilling injury, loss of moisture, and pesticide residues are examples. In such cases, either of several or a group of commodities may be selected for study, depending upon convenience, availability, or local importance. Also unusual or local conditions may present special problems locally. The State Experiment Stations are likely to supply the research in such cases.

### USDA PROGRAM

The Department has a continuing long-term program at Savannah, Georgia, involving entomologists and chemists engaged in basic and developmental studies directed toward the solution of the problems of insect infestation, damage, and contamination of agricultural commodities and their manufactured or processed products in the marketing channels. The research is conducted in cooperation with the Entomology Research Division and the Utilization Research and Development Divisions of the Agricultural Research Service, the Commodity Credit Corporation, several branches of the Department of Defense through the Armed Forces Pest Control Board, several of the State Agricultural Experiment Stations and Universities, the U. S. Public Health Service, the Fish and Wildlife Service of the Department of Interior, and many individual firms and trade associations in a variety of industries.

The Federal scientific effort charged directly to this area totals 2.4 professional man-years. Of this number, 2.1 is devoted to nonchemical control at Savannah and 0.3 to program leadership at Beltsville, Maryland. The remainder of the program at Savannah has direct or indirect bearing on several commodity areas to varying degrees. Most of the progress is reported in Area 13 for the sake of continuity and clarity. The manpower has not been assessed against Area 13, but the professional man-years have been apportioned to other areas as follows: 1.2 to Area 2, Dairy Products; 1.2 to Area 3, Deciduous Fruits and Tree Nuts; 7.4 to Area 4, Grain; 1.2 to Area 4a, Rice; 1.5 to Area 6, Oilseeds and Peanuts; 2.0 to Area 8, Wool and Mohair; and 0.4 to Area 11, Tobacco. The work on evaluation of equipment for applying insecticides to control stored-product insects, conducted under Line Project BS 1-53, was discontinued during the reporting period.

### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State Experiment Stations in 1961 did not report any work on insect control in marketing channels of a cross-commodity nature. However, they reported 7.0 professional man-years on other work of a cross commodity nature, divided as follows: Objective measurement and evaluation of quality 2.1, handling and packaging 1.4, storage 1.2, and post-harvest physiology 2.3.

Industry and other organizations. Several chemical companies, engaged in the formulation of insecticides, do some research in this area both directly and in cooperation with the Department. Estimated annual expenditures are equivalent to approximately 5 professional man-years. Also professional or trade groups do some research in this area perhaps equal in amount to that done by the chemical companies.



REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Because most of the work in this area applies equally well to several different commodities, the major part of the manpower for this research has been allocated on a proportionate basis to areas concerned. It is not feasible to report only a portion of the results under the respective areas, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is given here and at the end of each major heading the areas are listed in which the information should be of interest.

A. Basic biology, ecology, and physiology.

1. Nutritional Requirements of Mites. A P.L. 480 project with the Central College of Agriculture in Warsaw, Poland, is developing extensive information on the nutritional requirements of 3 species of mites of importance to stored products. Results show that diet greatly and promptly affects the fecundity of females. There are significant differences between the three species in their diet requirements. These mites, unlike insects, apparently do not require cholesterol in their diet. All three species require protein, carbohydrate and fat, certain vitamins, and mineral salts. Tyrophagus infestans (Ouds.) did well when the protein was casein, gluten, gelatin, or a mixture of the three. Glucose, saccharose, or starch were satisfactory carbohydrates. The best diets contained fats or oils such as beef fat, flax oil, or rape oil. Butter and soybean oil were less satisfactory. Vitamin K, inositol, and Vitamin PP or its precursor tryptophan did not appear to be essential. Carpoglyphus lactis (L.) did best with gelatin as the protein. Gluten or casein seemed much inferior. Vitamin K and inositol seemed to be essential. Another unknown but very important food component is indicated and has not yet been identified. Acarus siro L. did well on casein, gluten, albumin, or a mixture of the three as the protein food source. Better results were obtained with a mixture of simple sugars than with starch. (E21-AMS-1(a))

This information should be of interest in Areas 2, 3, 4, 4a, 6, and 11.

B. Insecticide evaluation.

1. Contact, Residual, and Vapor Evaluations. Of the compounds tested in 1961 using flour beetle adults and black carpet beetle larvae as the test insects, Bayer 34727 and Bayer 39193 were the most promising. The most promising formulation was a Bayer 29493 wettable powder, requiring about one-third the rate of application as malathion to give equal effect. A commercial paint containing TDE gave effective residual activity against cigarette beetle adults but was one-third less effective after aging 28 days. The red flour beetle was found more susceptible to malathion and pyrethrum than the confused flour beetle. (MQ 1-23)

The relatively new insecticides Bayer 29493, DDVP, and naled were evaluated against the Indian-meal moth for vapor toxicity to eggs; contact, residual, and vapor toxicity to larvae; and contact and vapor toxicity to adults. In general, these compounds were more effective than malathion and in order of speed of action were DDVP, naled, and Bayer 29493. The relative persistence as residues was in the reverse order. The extremely fast killing action of DDVP and naled



against the adult moths prevented oviposition before death as occurs with slower acting insecticides. Diazinon as a vapor toxicant against Indian-meal moth larvae was slightly slower in action than DDVP but faster than malathion or lindane. (MQ 1-23)

Of 28 compounds evaluated for contact, residue, and vapor action in 1962, 21 showed one or more toxic properties worthy of further attention. The most promising one for all three types of action was Monsanto CP 40273. The most effective residual toxicants were Monsanto compounds CP 40272 and CP 40294.

Exploratory direct contact spray tests were conducted with 35 other compounds and Shell SD 8447 was the most effective. The promising materials will receive additional testing. (MQ 1-23)

The development of several insecticides that have high vapor toxicity has stimulated emphasis on research directed toward using this vapor action against stored-product insects. Preliminary comparisons indicated considerable promise for DDVP and two aerosol formulations were developed. Both gave high initial effectiveness with subsequent vapor toxicity, the latter apparently resulting from volatilization of the toxicant from deposited aerosol particles. Other formulations were designed to accelerate DDVP vaporization and reduce the possibility of food contamination. Tests showed that unpackaged grains, flour, cheese, nonfat dry milk, dried fruit, peanuts, and dried citrus pulp animal feed sorbed DDVP when exposed to a relatively high aerosol dosage but that residues tended to disappear rather rapidly. (MQ 1-24)

With the development of a suitable chemical analytical method for measuring the concentration of DDVP in the air, it was possible to determine more specifically its biological effectiveness against stored-product insects. Testing revealed that relatively high DDVP vapor concentrations in air can be attained immediately after application either with aerosols or direct vapor dispensation, but rapid dissipation of vapor in the air brings about low concentrations within 4 to 6 hours after application. Vapor concentrations from aerosol applications persist at a level about 5 times greater than those from a comparable rate of direct vapor application, and biological efficacy is directly related to concentration of DDVP in the air, regardless of the method of application. Tests with various "static" methods of dispensing DDVP vapor showed that the resulting concentration in air depended in part on the volume of formulation used and on the rate of air movement through the holder for the formulation. It was possible to maintain a relatively constant level for four weeks with some types of dispensers. (MQ 1-24)

Research on DDVP in 1962 established time-concentration relationships for adult confused flour beetles. It was found that concentrations of 4.0, 2.7, and 1.9 micrograms of DDVP per liter would kill 95% of the beetles in 4, 8, and 12 hours respectively. Tests with adult cigarette beetles and black carpet beetle larvae have not yet provided adequate mortality data for establishing time-concentration relationships. The cigarette-beetle tests have yielded some puzzling results and the carpet beetle larvae are more highly resistant to DDVP than are other species tested. There is indication of delayed mortality with both species and extending the post-exposure observation period may clarify the situation. (MQ 1-24)

Residue tests were conducted with packaged flour, sugar, nonfat dry milk, raisins, milled rice, and dry beans after exposure to DDVP at comparable levels of air concentrations from single vapor and aerosol applications, from triple aerosol applications followed by 6 weeks of storage, and from multiple aerosol applications. Residues on commodities and packaging materials from a concentration of 2.0 to 5.5 micrograms per liter in the air were about the same whether the DDVP was applied as an aerosol or as a vapor. There was differential sorption of DDVP by different materials. Residues were highest on burlap bagging and in flour in cotton bags. Packaged commodities exposed to concentrations effective against most stored-product insects did not usually contain more than 0.6 p.p.m. of DDVP and this decreased rapidly. DDVP did not migrate from the packaging material to increase the residue in the commodity during storage. (MQ 1-24)

In comparative toxicity studies using adult confused flour beetles, DDVP was more toxic than naled as a direct-contact spray and oil-base formulations were more effective than those with a water base. In residue tests naled was more persistent and both toxicants were more effective in the water-base formulations. In the vapor toxicity tests DDVP and naled concentrations were monitored by chemical analysis. DDVP had greater vapor toxicity. Formulations containing methylene chloride resulted in higher vapor concentrations than did the corresponding water-base formulations. (MQ 1-24)

2. Fumigant Evaluations. During 1961 tests on eight candidate fumigants were completed. Minimum lethal concentrations for adult flour beetles, Tribolium spp., exposed 24 hours in empty 19.5-liter fumatoria at  $80^{\circ} \pm 4^{\circ}$  F. were calculated as follows: Acrylonitrile - 1.27 mg./l.; methylamine (30-percent aqueous solution) - 3.78 mg./l.; Dowfume EB-5 - 13.36 mg./l.; carbon tetrachloride - 65.2 mg./l.; chloroform - 75.7 mg./l.; and ethylene diamine - 154.7 mg./l. Minimum lethal concentrations for flour beetle larvae under the same conditions were calculated as follows: Acrylonitrile - 2.12 mg./l. and methylamine (30-percent aqueous solution) - 2.36 mg./l. Minimum lethal concentrations for acrylonitrile to adult flour beetles exposed for 18 and 5 hours were 1.27 mg./l. and 2.54 mg./l., respectively. (MQ 1-28)

Experiments have been completed and data obtained for determining the LD<sub>50</sub>, LD<sub>95</sub>, and minimum lethal concentration values for acrylonitrile, ENT-25767 (Wyandotte W-24), and carbon tetrachloride against the adult confused flour beetle, cigarette beetle, and saw-toothed grain beetle, and against larvae of the black carpet beetle. The data have been submitted to the Cornell University Computing Center for probit analysis by electronic data processing. (MQ 1-28)

During 1962 LD values and dosage-mortality regression lines were determined for acrylonitrile, diethylamine, Substanz 215 (acetate of dimethyl 2,2-dichloro-1-hydroxyvinylphosphonate), Wyandotte W-24 (N-(alpha-methylacetonitrile)-morpholine), carbon tetrachloride, and methylamine (30-percent aqueous) to adult confused flour beetles, adult cigarette beetles, adult saw-toothed grain beetles, and black carpet beetle larvae. Wyandotte W-24 and Substanz 215 were the most toxic to saw-toothed grain beetles. Substanz 215, Wyandotte W-24, and acrylonitrile were the most toxic to confused flour beetles, cigarette beetles, and black carpet beetles, respectively. Based on the average of their MLD values to all insect species, the order of decreasing toxicity of the chemicals was



acrylonitrile, Substanz 215 = Wyandotte W-24, diethylamine = methylamine (30-percent aqueous), and carbon tetrachloride. Data to determine LD<sub>50</sub>, LD<sub>95</sub>, and MLD values for methyl bromide, ethylene imine, and Michigan Chemical compounds 2224 and 2209 were obtained for the previously listed test insects and sent to the Cornell University Computing Center for statistical analysis. (MQ 1-28)

Preliminary "range-finding" tests against the previously listed test insects have been completed for the following candidate fumigants: DDVP, naled, Shell SD-2218, isoamylamine, ethylamine, triethylamine, methyldisulfide, Freon MF, Freon TF, Bayer 20743, ENT-25407, Stauffer R-3413, diazinon, ethylene diamine, methylene chloride, Stauffer B-8760, Stauffer B-8778, Bayer 16574, Bayer 16948, Shell SD-7169, Bayer 41831, Bayer 38420, Bayer 29493, and Bayer 19596. Tests have been initiated to determine the relative toxicity of acrylonitrile, diethylamine, Substanz 215, Wyandotte W-24, carbon tetrachloride, and methylamine (30-percent aqueous) to confused flour beetle larvae. (MQ 1-28).

Manpower for insecticide evaluation has been apportioned to areas 2, 3, 4, 4a, 6, 8, and 11, and the preceding information will be applicable to the commodities involved.

#### C. Insecticidal control.

The major effort of the project dealing with equipment for applying pesticides to control stored-product insects was devoted to the development of specialized equipment required for dispensing vapor toxicants such as DDVP. The results are discussed in connection with Line Project MQ 1-24 under Insecticide Evaluation. Evaluation tests with the Hudson Roto-Fog Sprayer No. 344 showed limited potential for use against stored-product insects. (BS 1-53)

#### D. Insecticide residues.

1. Chemical Analysis. Chemical residue analyses were conducted at Savannah, Georgia, on 2,600 samples involving 11 different agricultural commodities and 10 different insecticides during 1961. Peanut samples from the studies on malathion protective treatments made up the greatest volume. The data from these analyses played a major part in the decision of the Food and Drug Administration to change the 8 p.p.m. tolerance from the unshelled peanuts to the shelled product. Improved and more efficient procedures enabled the Chemical Unit to more than double the number of analyses in 1962 over 1961. In 1962, analyses of DDVP concentrations in air and as residues in food products constituted the greatest volume of samples. This program was closely coordinated with the entomological research in Line Project MQ 1-24 reported under Insecticide Evaluation. The Chemical Unit is preparing a simplified step-by-step manual of analytical procedures used in their operations. It also contains modifications that may have been developed to meet specific needs of the project, as well as extraction procedures for the particular commodities involved in the program. The manual has been completed except for the procedures for methoxychlor. It will not only be useful to the Chemical Unit, but will be a valuable reference for the field stations and for cooperators. (MQ 1-29)

2. Malathion. A P.L. 480 contract with the University of Helsinki, Finland, is providing valuable information on post-harvest residues of malathion.



Studies on the effects of temperature showed that 90 percent of the malathion residue on beans disappeared during one week at 20° C., but only about 40 percent disappeared during the same time at 4° C. No significant loss of malathion residue occurred during frozen storage of beans. Heating at processing temperatures destroyed malathion residue almost completely. Eighty percent of the malathion residue disappeared from apples stored one week at 20° C., and about 60 percent at 4° C. There was no significant loss from frozen apples. Preservation processes involving heating destroyed more than 90 percent of the malathion. (E8-AMS-1(a))

Tests with fresh and cooked products indicate that an enzyme system in plant cells catalyzes the breakdown of malathion. The enzyme activity is inhibited by paraoxon. Tests on the extractibility of malathion from plant materials with pH values of 3 to 6, using benzene with or without ethanol as the solvent, indicated that pH had no effect on extraction of malathion. The addition of ethanol to the benzene tended to increase the malathion yields. Progress has been made in using P<sup>32</sup>-labelled malathion to study the degradation mechanism. Degradation products were separated and identified by the ion exchange technique and migration of labelled malathion was studied in apples and lettuce by autoradiography. (E8-AMS-1(a))

The manpower for Insecticide Residue Analysis has been apportioned to areas 2, 3, 4, 4a, 6, and 8, and much of the preceding information will be applicable to the commodities involved.

#### E. Nonchemical control.

Results of a field test in a feed warehouse in Florida with Bacillus thuringiensis indicated promise for this means of biological control in preventing or reducing infestations of Ephestia cautella. The bacillus had no apparent effect on the beetle species infesting the feed. (MQ 1-25)

Studies of the responses of stored-product insects to light traps showed that adult red flour beetles were attracted by light from black-light, argon-glow, and incandescent lamps, with preference in the order listed. There was no significant difference in response to a steady light and one that flickered 120 times per second as with a 60-cycle alternating current. Light of the highest intensity was most rapidly attractive. Males and newly emerged adults responded to black light more rapidly than did females and older adults. It might be possible, therefore, to trap newly emerged adults before they mate and lay eggs. Black light attracted adult black carpet beetles and repelled the larvae. Adult females responded more rapidly than males. AC- and DC-operated black-light and argon-glow lamps were operated in a room infested with large numbers of 17 species of stored-product insects to determine the response of the various species to the lights. Indian-meal moths, rice weevils, lesser grain borers, saw-toothed grain beetles, flour beetles, and cigarette beetles were attracted to the lights. There was no significant preference between the flickering light from AC and the steady light from DC. (MQ 1-12)

A P.L. 480 project by the Institute of Plant Protection in Poznan, Poland, has recently been initiated to study the possible use of Bacillus thuringiensis to

control the Indian-meal moth or the Mediterranean flour moth. It is not yet time for the first progress report. (E21-AMS-4(a))

This information will be of interest in areas 2, 3, 4, 4a, 6, 8, and 11.

#### F. Insect-resistant packaging.

1. Repellent Evaluation. Of the 309 candidate repellents evaluated, 34 showed sufficient promise to warrant further study. It is of interest that many of the promising compounds are imides, a group that the Fish and Wildlife Service found to contain some effective rodent repellents. A treatment that would make food packages repellent to both insects and rodents would be highly desirable. (MQ 1-20)

The Midwest Research Institute in Kansas City, Missouri, under contract, is analyzing critically the experimental data accumulated in the evaluation tests of repellents at Savannah, Georgia. One major objective is to determine whether chemical structure or physical properties of compounds are associated with repellency to stored-product insects. Some tentative conclusions are that most of the effective repellents are solids at room temperature. A significantly greater number of the effective compounds have a molecular weight of 151-270 and either 3 or 4 reactive sites more than would be observed in random sampling. In the N-substituted phthalimides there is a trend to ward a lower melting point and lower repellency as the length of the carbon chain in the N-substituent is increased to 7 carbons. A number of effective compounds have the nitro group meta to another group on a benzene ring. This has suggested 33 new compounds for testing. In a group of 6 of the most highly repellent compounds, one had 3 of these m-nitro groups. All contained nitrogen and either oxygen or sulfur. All but one had a ring structure, and all were low melting solids. Coding has been developed for a punchcard system for the compounds evaluated in the repellency program. This will permit rapid retrieval of many kinds of information for use in subsequent research. (MQ 1-11(C))

2. Storage Tests. Storage tests were completed in 1961 with kraft paper packets treated with five different promising repellents. Two of the compounds failed to provide as much protection as did synergized pyrethrum used as the standard for comparison, one was about equal to the standard, and two offered greater protection against penetration and infestation. The latter compounds were ENT-21170 (chrysanthemumic acid, 2,4-dimethylbenzyl ester) and ENT-21195 (chrysanthemumic acid, 6-bromopiperonyl ester). Other tests with treated kraft paper packets showed that ENT-1186 (N-phenylmaleimide) offered only slightly less protection after 9 months of exposure than did the synergized pyrethrum used as the standard. After 1 year of exposure a coating of Sevin (1-naphthyl methylcarbamate) completely protected packets against insect invasion and penetration. (MQ 1-21)

In large-scale tests, pyrethrum dust applied inside shipping cases to prevent insect invasion proved completely ineffective. Another problem of insect infestation in marketing channels has been the attack, chiefly by cigarette beetles, on blocks of animal feed concentrates. The insects not only damaged the feed but newly emerging adults chewed holes through the paper wrapper making the product unsalable. Tests with feed blocks stored in wrappers with the



inner surface treated with malathion at the rate of 200 mg. per sq. ft. showed that the treatment resisted infestation even though exposed to heavy insect populations, and the feed remained in salable condition for 5 to more than 12 months. (MQ 1-17)

The insect-resistant packaging research at Savannah, Georgia, has demonstrated repeatedly that tight end closures on multiwall bags are required to prevent insect invasion, even in combination with the best repellent treatments now available. There have been bags available with good closures at the bottom but there was no provision for applying a similar closure at the top after the bags were filled with a product. This was brought to the attention of the packaging industry through publications and by discussions with a number of cooperators. As a result, and also because of similar needs for tight closures for bagged hygroscopic products in commerce, several companies put their packaging engineers to work on the problem. There are now closures and machines for applying them available from several different firms, all at reasonable cost. They all use the principle of a sealed tape over stitching, the type of closure advocated by the entomologists working on insect-resistant packaging. Thus the results of this research program have been a major factor in bringing about an important commercial development that marks a significant advance in the ability to prevent insect infestation of food products in the marketing channels. This will be of tremendous benefit to consumers of products packaged in multiwall paper bags. (MQ 1-17)

The commercially available new systems for bag closure are of 3 basic types. One, developed by the Hudson Pulp and Paper Company, known as their MVT closure, uses a polyethylene-laminated tape that is heat sealed over the bag stitching. Multiwall paper bags with a methoxychlor coating on the outer ply and with the Hudson MVT closure have been in a long-term storage test at Savannah, Georgia, under constant exposure to heavy populations of 17 different species of stored-product insects. There has been complete protection against insect invasion for at least 2 years. This is the best protection against insect contamination provided by any kraft bag evaluated in this research program. The Crown-Zellerbach Corporation has a similar polyethylene-laminated tape system which they call the Thermo-Tape closure. Their machine for applying the closure differs from the Hudson equipment in having a different type of head and a different pressure shoe for making the heat seal. The Bemis Brothers Bag Company has a system designated as Bemistape 400, which uses a hot-melt adhesive mixture of plastic resins coated on the tape to be heat sealed over the stitching. During a 1-year-exposure storage test the Bemistape 400 gave better protection against insect invasion than did wax-dipped stitching, oversewn tape closures, or a Bemis 100 closure, which is a pressure-sensitive tape. The third type of closure is the Thermogrip system of the United Shoe Machinery Corporation. It uses the principle of flowing molten polyethylene onto the bag stitching and tape just before the pressure shoe applies the heat seal. This type of closure has been under test for a shorter period of time but has given complete protection against insect invasion thus far. (MQ 1-17)

Tests conducted cooperatively by the Savannah and Madison laboratories, with dried milk in polyethylene bags and in shell cartons used in the school lunch program, indicated that the polyethylene bags offered some protection against insect invasion. The milk in the shell cartons was heavily infested after 3



months' exposure to an intense infestation of stored-product insects. In a test with dried prunes conducted cooperatively by the Savannah and Fresno laboratories, cartons with a foil-paper laminated overwrap completely glued to the exterior with an aqueous adhesive showed the greatest protection against insect invasion of 7 different overwraps tried. Shipping cases of experimental design, prepared by an industry research laboratory, having siftproof tear corners and compressed overlapping glue flaps, gave no greater protection than was provided by standard cases. Packets sealed on all sides with a new tape coated with an adhesive that seals only to itself remained effective for 1 year and completely prevented insect invasion. (MQ 1-22)

Eighty flexible packaging materials have been evaluated in a program to determine their comparative resistance to insect penetration. Resistance has been found to vary from 16 hours for 50-lb. (BW) kraft paper to 68 days for 8-mil polyethylene film. Relative resistance to penetration was determined on the basis of time required for insect penetration in laboratory tests. Good correlation in experimental results was shown in concurrent tests conducted with small bags exposed under simulated warehouse conditions. Those films which showed greatest resistance to insect penetration in laboratory evaluation tests also showed the greatest resistance in the simulated warehouse tests. Packages formed of an experimental "Scotchpak" film have provided protection against penetration and infestation for 3 years. (MQ 1-22)

A number of special formulations and coatings were prepared at Savannah for use at other stations. These included kraft paper treated for evaluation as repellent barriers against cigarette beetles in tobacco hogsheads, impregnations on paper to be used as raisin drying trays, and various treatments on shipping cases for test at Fresno, Madison, and Savannah. Six different paper coatings were prepared for testing that contained resins and synergized pyrethrum. None of the resins extended the repellency of pyrethrum in preliminary laboratory evaluations conducted under Line Project MQ 1-20. Occasional effort has been devoted to developing an economical, satisfactory ninhydrin-treated tape for use in the machine for detecting internal insect infestation in grain. Kraft and mimeograph paper were treated and the rolls of paper were slit and rewound at a commercial facility. When used in the machine the kraft paper was too stiff for the guide and folding apparatus. The mimeograph paper tore when subjected to the crushing action of the rolls. (MQ 1-1)

A means of preventing migration of chemicals from package coatings into the commodity would permit greater choice of treatments to increase the insect resistance. Several flexible packaging materials have been evaluated as potential barriers to migration. Some films of polyvinyl chloride, polyethylene terephthalate, and cellulose triacetate have appeared to be effective barriers to the migration of malathion for at least 6 months in a laboratory test still in progress. The same films and a polymer-coated cellophane prevented or significantly reduced the migration of methoxychlor for 1 year. (MQ 1-1)

The manpower for insect-resistant packaging research has been apportioned to areas 2, 3, 4, and 4a, and the preceding information will be applicable to the commodities involved. The information will also be of interest in area 6.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Insecticide Evaluation.

Speirs, Roy D. 1960. The effectiveness of sevin-sesamex combinations against adult flour beetles (Tribolium spp.). Journal Economic Entomology 53(5), pp. 974. (MQ 1-23)

Speirs, Roy D. 1962. Contact, residue, and vapor toxicity of new insecticides to stored-product insects. Marketing Research Report No. 546, U.S.D.A., 31 pages. (MQ 1-23)

General.

Henderson, L. S. 1960. Use of insecticides to protect stored grains, fruits, and vegetables. In, the Nature and Fate of Chemicals Applied to Soils, Plants, and Animals. Agricultural Research Service ARS 20-9, pp. 84-92. (MQ 1)

Laudani, Hamilton. 1961. Biology and habits of dermestids. Pest Control 29(10): 58-61. (MQ 1)

#### AREA 14. INSTRUMENTATION FOR OBJECTIVE MEASUREMENT OF MARKET QUALITY

Problem. Agricultural commodities vary widely in many of the factors that determine market quality. A continuing need exists for more and better instruments for use in the marketing of agricultural commodities. This need includes instruments to measure color, moisture content, texture, maturity, composition; and to detect defects in a wide range of commodities. These instruments are needed by inspection and grading services, by food handlers and processors, and by research workers in the broad field of agricultural marketing. The development of techniques of measurement suitable for use in automatic sorting is included in this area. The rapid conversion to mechanical handling of agricultural commodities makes it imperative that automatic devices be developed to evaluate and control the quality of the product.

#### USDA PROGRAM

The Department has a continuing program involving engineers and physicists engaged in the broad field of instrumentation, procedures and methods for use in basic and applied research on market quality of agricultural products. This work supplements other marketing research through superior instrumentation designed for the specific problem under study, and is cooperative with ARS and other agencies of the Government.

The Federal scientific effort devoted to research in this area totals 5 professional man-years.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 3.6 professional man-years in research to develop instrumentation for the objective measurement of quality in progress. This work concerns radiochemical methods for detecting pesticides and food additives before, during and after processing, and also deals with the applicability of mass spectrometry, infrared, fluorescence microscopy and other instruments as means of further increasing resolution and sensitivity of detecting residues and additives. These methods are being used to ascertain their values in determining physiological changes in fruits and vegetables.



Industry and other organizations also carry out research on the development of new and improved instruments specifically for use in agricultural marketing operations. In addition many companies are developing instruments for multiple use, some of which are in the marketing field. These manufacturers carry on all of the work and the progress is kept confidential until the instruments are marketed. The estimated annual expenditures for instrumentation specifically for use in agricultural marketing are equivalent to approximately 15 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Objective Measurement and Evaluation of Quality

1. Optical Effects of Light Scatter. Much of the work of the Instrumentation Research Laboratory involves the measurement of light transmitted through light-scattering samples. This has required the development of new methods of measurement and of new theoretical concepts. One of the areas where pioneering research was required was the quantitative determination of the effects of light scatter on the absorption spectra of turbid materials. These studies were carried out by measuring the absorption spectra of solutions of pigments which were added to suspensions of  $\text{CaCO}_3$  and other nonabsorbing scattering media. It was found that the light scatter increased the optical pathlength through the sample resulting in an intensification of the absorption band of the added pigment. There was no theoretical basis for this intensification, however, and the factors which determined its magnitude were unknown. The mathematical formulation for the optics of scattering materials was developed to account for the intensification and the formulas were tested experimentally. The theory, as developed, was confirmed experimentally and we can now predict the extent of the intensification from measurable parameters.

2. Fluorescence Excitation Spectra. New methods for measuring fluorescence excitation spectra of intact, light-scattering samples as well as clear solutions have been developed in the Instrumentation Research Laboratory. Fluorescence excitation spectroscopy is more sensitive to the presence of minute quantities of fluorescing compounds than is absorption spectroscopy, and these measurements provide additional information such as the resonance transfer of energy from other light-absorbing materials to the fluorescing compound and a measure of relative fluorescence yields. These methods have been employed in an investigation of the photochemical apparatus of green plants and have provided new information of considerable importance to the understanding of the mechanism of photosynthesis.

In fully green plants the light energy absorbed by carotenoid pigments can be transferred to chlorophyll a for photosynthesis. This capacity

for energy transfer has been measured in the leaves of etiolated seedling plants and followed as the leaves green in light. These measurements have shown that the energy transfer capacity develops as the leaf greens and has been related to known chemical and structural changes in the developing chloroplasts. These studies have led to several significant conclusions as to the structural development of chloroplasts and the photochemistry of photosynthesis.

Fluorescence excitation spectra of fully green leaves revealed the presence of a small amount of a chlorophyll absorbing at 705 m $\mu$ , C-705, whereas the large amount of chlorophyll a present absorbs at 680 m $\mu$ . The measurements also showed that most of the light absorbed by the chlorophyll a can be transferred to the small amount of C-705. This suggests that C-705 is the focus of photochemical activity in photosynthesis since most of the absorbed light energy can be concentrated at the relatively few C-705 molecules. These findings give strong support to the theory that energy is transferred within the chloroplast by inductive resonance to particular reaction centers of photochemical activity.

Further indications of the role of C-705 have come from measurements of the fluorescence yield of chlorophyll a. Red light increases the yield and far-red light decreases the yield. The action spectrum for the effect of far-red light showed that C-705 mediated this response.

3. Orientation of Chlorophyll Molecules *in vivo*. The measurements on the fluorescence of C-705 suggested that this emission might be observed from intact chloroplasts with a microscope if an infrared image converter were used to convert the infrared emission to visible light. These experiments, which were done in cooperation with the Laboratory of Physical Biology at the National Institutes of Health, showed that the infrared emission was polarized, whereas, the fluorescence from chlorophyll a was not. Measurements of dichroism on intact chloroplasts showed that the polarized fluorescence was due to a 705-m $\mu$ -absorbing pigment (presumably C-705) which was oriented in the lamellar planes of the chloroplast. These measurements also demonstrated that energy was transferred from the main bulk of the chlorophyll a to the small amount of C-705.

4. Fluorescence Lifetime Measurements. The lifetime of the emission,  $\tau$ , from the C-705 molecules was measured in order to determine whether the emission was phosphorescence from an excited triplet state ( $\tau \approx 10^{-4}$ sec) or fluorescence from a singlet state ( $\tau \approx 10^{-8}$ sec). Measurements of the time decay of the emission following excitation with a brief flash showed that the lifetime was less than  $5 \times 10^{-8}$ sec. In order to measure shorter lifetimes, a phase fluorimeter was constructed. In this instrument, fluorescence was excited with a light beam which was modulated at 13.0 megacycles and the phase difference between the exciting light and the fluorescence emission was measured.



The lifetime, computed from the phase shift, was  $3.1 \times 10^{-9}$  sec. This very short lifetime indicates that the emission is from a  $\pi - \pi^*$  singlet state of the C-705 molecules.

5. Phytochrome. The red-far-red photoreversible pigment which controls so many aspects of plant development including seed germination, flowering, growth, and pigmentation was detected spectrophotometrically with instruments developed in this Laboratory. These measurements have permitted this pigment which has been named phytochrome to be extracted from plant material and studied in vitro. Our work on phytochrome has continued in cooperation with the Plant Physiology Laboratory and the Mineral Nutrition Laboratory of ARS, and to date has been largely directed toward the study of the photochemical properties of this pigment.

Action spectra for the photochemical transformation between the two forms of phytochrome were measured throughout the visible spectrum. Measurements in the red established that the  $P_{660} \rightarrow P_{730}$  conversion was 3 to 4 times as efficient as the  $P_{730} \rightarrow P_{660}$  conversion. Measurements in the blue showed that both  $P_{660}$  and  $P_{730}$  absorbed in the blue and near ultraviolet regions of the spectrum, but with much lower extinction coefficients than in the red. Absolute absorption spectra measurements on purified solutions of phytochrome agreed entirely with the results of the action spectra measurements. Difference spectra between  $P_{660}$  and  $P_{730}$  showed maxima at 660 and 360 m $\mu$  and minima at 730, 410, and 320 m $\mu$  with isosbestic points at 800, 690, 520, 390, 340 and 300 m $\mu$ . Below 300 m $\mu$  both forms have an intense absorption band at 280 m $\mu$  due to the protein part of the pigment.

$P_{660}$  fluoresces but  $P_{730}$  does not. Fluorescence measurements indicated that red light did not convert all of the  $P_{660}$  to  $P_{730}$ . Absolute measurements of the absorption spectrum of phytochrome solutions confirmed that only about one half of the absorption band at 660 m $\mu$  is converted by red light. There appears to be an irreversible form of  $P_{660}$  which does not take part in the photochemistry.

In the course of purifying phytochrome from barley seedlings, it was noted that the absorptivity of the far-red-absorbing form decreased and shifted to shorter wavelength during the purification. Preparations from corn seedlings did not show this change and were much more stable than the phytochrome solutions from barley. The altered far-red-absorbing form, however, was produced in the phytochrome solutions from corn by treating them with trypsin or urea which denatured the protein. Denaturation resulted in the loss of both the 660- and the 730-m $\mu$ -absorption bands. Phytochrome was much more resistant to the denaturing agents in the  $P_{660}$  form. These experiments showed that the absorption spectrum of the chromophoric group depends greatly on protein to which it is bound and that the configuration of the protein in the  $P_{660}$  form is more resistant to denaturation than the configuration in the  $P_{730}$  or altered  $P_{730}$  form.



Dark reactions involving phytochrome have been studied in intact corn seedlings. Phytochrome is entirely in the P<sub>660</sub> form in dark-grown seedling plants. After a single brief irradiation of such plants with red light, the P<sub>730</sub> which is formed by the light converts back to P<sub>660</sub> in the dark in about four hours. During this period of dark conversion, about two thirds of the phytochrome is lost. The dark conversion of P<sub>730</sub> → P<sub>660</sub> affords the plant a means of measuring the length of a dark period and is the basic time-sensing mechanism for all photoperiodic responses. This conversion does not occur if the plants are near 0°C. or in nitrogen. The rate of conversion depends upon the metabolism of the plant and is probably different for different plants.

The loss of phytochrome following irradiation of etiolated plants probably does not occur in mature green plants. Phytochrome has been extracted from green plants, although in much smaller amounts than from dark-grown seedlings. The loss of phytochrome was studied by putting dark-grown corn seedlings in continuous light so that a certain amount of P<sub>730</sub> would be maintained at all times. If phytochrome is entirely in the P<sub>660</sub> form, no loss of pigment occurs. By using different qualities of light, it was found that the decay reactions were saturated when as little as one to two percent of the phytochrome was present as P<sub>730</sub>. With smaller amounts of P<sub>730</sub>, the rate of decay was less.

6. Color Sorting of Granular Materials. Color sorting of granular materials on a mass basis may be possible. Since the present separation method is on an individual basis, separation on a mass basis would increase the speed of the operation and simplify the mechanism. A device for mass color sorting is under development for the separation of "pecky" rice kernels from the sound grain.

Mass separation of granular materials differs from the present method of sensing the color of the individual particle since the color of the individual particle will cause an increase in temperature when irradiated with light energy. This increase in heat can be used as a means of separation since darker colors will absorb more energy and their temperature will increase. If the particles are then placed on a thermosensitive material, the higher temperature particle will adhere while those with temperatures below the tacky point of the thermosensitive materials will not adhere.

To accomplish this color separation requires a high intensity radiation source with uniform field, a filter to eliminate long wavelength energy, thermosensitive material that becomes "tacky" at the temperature of the particle to be separated, a feeding mechanism to place the particle in a single layer of one particle depth, and a conveying mechanism.

A commercial vibratory feeder has been adapted to feed a single layer of grain along a flat bottom trough during irradiation. The kernels then drop onto the endless belt. A mirror serves as the trough bottom and reflects the energy to the underside of the grain, and reduces the heat absorbed by the trough.

A photographic sun-gun lamp was used as a radiation source with limited success on the working unit. A source (1500-watt tungsten-in-quartz) of greater intensity and more uniform energy distribution was acquired to increase the temperature of the "pecky" grains, enough to cause them to adhere to the thermosensitive material. Since the housing and holder for this energy source have larger dimensions, the feeder must be rebuilt before further tests are made. A water filter is used to remove the longer wavelength infrared radiation to prevent heating of all rice grains.

Thermoplastic polymers with a softening or tacky point from 50 to 100°C. have been used as an adhering material. Difficulties have been experienced with obtaining a surface that is flexible and easily applied but the results are promising. This material must have a tacky point of 30° to 40°C. above ambient, must be easily applied and flexible enough to remain on an endless flat belt to convey the grain after exposure to the radiation source.

A radiometer serves as a temperature monitor for development purposes. It is an optical device that does not require contact with the grain. It is focused to measure the grain temperature immediately after leaving the vibrating trough. Temperatures of rice grains varying in color from white, brown-tip, all brown and black (dyed with black ink) were measured with the radiometer while being irradiated with energy in the wavelength region from 500 to 1000 mμ. Radiation in the visible region from 500 to 700 mμ caused the greatest temperature differential. A temperature differential of 40°C. could be obtained depending upon the color and time of exposure. The darker colored grains had the greatest temperature increases.

Results of this development are encouraging and the increased energy source will be tested to determine if the temperature of the darkened rice grains increase fast enough that the temperature of other grains increase only slightly. Also, the thermosensitive belt coating must be selected or developed that will be easily applied, become tacky in the immediate area when grain at 50° to 75°C. is placed on the surface and the dark grain must become attached to the belt surface.

The potential of mass color sorting indicates that it could be adapted to other commodities. It is conceivable that the conveying belt could be wide enough to accommodate a large quantity of material. This color sorting principle could be adapted to separating foreign material from grain or separating material into varying shades of the same color.



7. Automatic Cotton Classing Recorder Simulator. In cooperation with the Cotton Division and Reports Branch, ASD, a device has been designed to simulate the entry of cotton grades and other related data on punch cards to be used for electronic processing methods. The objective is to test the feasibility of entering the cotton-classer's decision directly on punch cards, thus eliminating the manual recording of this information by clerical procedures and produce reports and records to meet the requirements of the Cotton Division.

At present, the classer examines the cotton sample and determines the quality, color, staple length and presence of foreign matter. Then, he relays this decision verbally to a clerk who records it manually by rubber stamping onto forms. When using this simulator, the classer will press a switch button for each of the above factors after sample examination. Each switch button will light when pressed and remain lighted until a switch is pressed that cancels the lighted buttons and clears the machine which prepares it for data entry from the next sample. Provision is made for indicating to the classer when the supervisor makes a sample check grade and when cards are rejected due to mutilation.

Construction of this Simulator is nearing completion. When finished, it will be tested by the Cotton Division, using experienced classers and selected samples. If the tests indicate that the system is satisfactory, a decision will be made on research and development of a prototype that will examine the data card for acceptance in an electronic data processing machine, signal its decision to the classer operator who will enter the cotton grade on the keyboard and actuate a card punch key that will key punch coded data and simultaneously print out readable information on the card. This would eliminate the present intermediate steps thereby reducing possible error and produce the coded data ready for analysis.

8. Portable Abridged Transmittance Instruments. A portable instrument (Difference Meter) for measuring the light transmittance of samples such as apples, potatoes, etc., at two wavelengths and computing the optical density difference was constructed during 1960. After about one year of use a completely new design was developed for the Difference Meter. Three additional instruments were constructed from this design. These Difference Meters employ a wheel holding two interference filters to isolate the respective wavelengths so the sample is illuminated alternately; first, wavelength A, then wavelength B, etc., with the wheel rotating at 1800 rpm. The switch which is used to identify the respective wavelengths in the circuit has presented some problems. The development of a new photometer in which the high voltage supplied to the phototube is alternating, and the appearance of the filters in the light beam is synchronized with the time during which the phototube is energized, has greatly simplified the circuit. The switching on the latest instrument employs a



photoswitch using a photoconductive cell so that solid state switching is used. This improves the noise appreciably. A noise level in the order of 0.0001 O.D. has been obtained on one instrument. Three instruments are now available for general purpose use on agricultural products and one instrument designed exclusively for the study of phytochrome.

An attachment was developed to rotate a bulk sample of granular materials while being measured in the Difference Meter. The purpose of this attachment is to remove some of the product variability. The device was used in tests for detecting mold damage in corn. Much better reproducibility is obtained with the rotating sample permitting measurements at higher sensitivities.

A study was made with apples to compare different methods of presenting samples to a light-transmittance instrument. The results indicated the parabolic mirror method of collecting light provided the greatest amount of energy to the phototube, the integrating sphere provided less energy to the phototube but more than the direct phototube presentation. However, the best correlation with chlorophyll content of the apples was obtained with the direct phototube presentation. Both the integrating sphere and the parabolic mirror techniques suffer from problems of light seal between the apple and the support. As a result, it is more difficult to obtain reproducible data with these presentations. The direct phototube presentation appears to be the most useful for general purpose measurements.

9. Evaluation of Apple Quality. During the past 2 years, about 5 man-months have been spent on the application of light transmittance techniques to the evaluation of quality of apples. Most of this work has been done with a portable Difference Meter. Most of the work with apple maturity is now being handled by the Horticultural Crops Branch personnel.

Tests were initiated at the Horticultural Crops Branch Field Station in Wenatchee, Washington, for using light transmittance to detect the presence of watercore. One of the new Difference Meters is being used in this work. The watercore measurement was quite temperature dependent; however, a new factor was introduced in the measurement to take advantage of the fact that the optical density of an apple at nearly all wavelengths is greatly influenced by the presence of watercore. This change made the measurement less temperature related, but more closely related to size. This is a favorable exchange because size is an easier variable to handle than temperature. This change also made it possible to operate the instrument at a lower sensitivity thus making the measurement less susceptible to errors caused by other variables.

10. Moisture Measurement. Cooperative work with personnel of the Field Crops and Animal Products Branch has resulted in the development of a spectrophotometric method for analysis of moisture content of grains and seeds. In this method the water is extracted with methanol after grinding of the sample and the moisture in the methanol is measured at 1.93 microns using a standard spectrophotometer. Further effort is now being devoted to a direct measurement without extraction. Preliminary tests with ground wheat resulted in a measurement with a standard error of  $\pm 0.3$  percent moisture content. This measurement was made using the water absorption band at  $0.97\mu$ .

The absorption bands at longer wavelengths are also being investigated.

Spectrophotometric measurements have also been made on individual beans and peanuts to determine if the moisture content of a single seed can be predicted. The results have been correlated with moisture content determined by oven drying. The tests have been encouraging, indicating an accuracy of about  $\pm 0.5$  percent, and several techniques are being explored for improving the results.

11. Peanut Counter. In cooperation with the Field Crops and Animal Products Branch, an electronic counter has been developed for counting peanuts. This unit, using a commercially available parts feeder combined with a specially developed semiconductor counting circuit, was developed for the Federal-State Inspection Service. The unit counts peanuts at a rate of 5 per second with an error of less than one count in 10,000. A commercial firm is now making these counters and they are being used in the peanut inspection program.

## B. Post-Harvest Physiology.

1. Low-Temperature Spectroscopy of Chloroplast Fragments. The resolution of absorption spectroscopy is greatly increased by cooling the sample to the temperature of liquid nitrogen ( $-196^{\circ}\text{C}.$ ). The chlorophyll band of green plants can be resolved into at least four components, chl b-650, chl a-670, chl a-680 and C-705. Experiments were undertaken in cooperation with the Pioneering Laboratory for Post Harvest Physiology to determine if these pigments were uniformly distributed throughout the chloroplast. Chloroplasts from leaves and algae were disrupted by ultrasonic oscillation and the various sizes of fragments were collected by differential centrifugation. The absorption spectra and fluorescence-excitation spectra were independent of the size of the fragments. These experiments showed that the various chlorophyll pigments were uniformly distributed throughout the chloroplast. They also supported the concept of a structural photosynthetic unit consisting of 100 to 200 chlorophyll a molecules for each C-705 molecule.

2. Instrument Developments. A multipurpose recording spectrophotometer of wide range and high sensitivity has been designed and constructed. This instrument will permit spectral absorption and fluorescence emission measurements to be made over the 200 to 1200 mμ region. Provision is included for normal spectrophotometry, as well as dual wavelength and derivative spectroscopy. Samples may range from clear solutions to intact fruits and vegetables. High response speed permits studies of reactions which occur in less than one second. Sensitivity and noise are such that an optical density change of less than 0.001 can be measured. This powerful research tool has already been very valuable on a number of research problems, and it will be widely used because it permits the study of very small pigment concentrations in intact tissues.

A method has been developed for greatly reducing the stray light from our previously developed recording spectrophotometers. A low-cost wedge-interference filter placed at the entrance slit, mechanically coupled to the wavelength drive of the monochromator reduces the stray light by a factor of 200 to 500 with only a 50 percent loss of energy. This development, combined with new photometer circuits of increased capabilities, further extends the usefulness of our spectrophotometers.

A high sensitivity gas chromatograph has been developed for measuring the ethylene content of storage atmospheres. This unit, using a flame-ionization detector combined with a commercial electrometer, provides a simple reliable instrument for routine work. A special gas chromatography unit has been constructed for studies with radioactive ethylene. A gas ionization chamber in series with a flame-ionization detector is used to provide analysis of both radioactive and nonradioactive components in a single pass through the instrument. Both of these gas chromatography units are being used by the Post-Harvest Physiology Laboratory in their studies of ethylene production of fruits and vegetables.



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## Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj.	Incl. in
			Summary of Progress	Area & Sub-Subheading
MQ 1	Methods for the prevention and control of insects attacking agricultural products in the marketing channels. Program Leadership	Beltsville, Md.		
MQ 1-1	Packaging insecticide formulation studies	Savannah, Ga.	Yes	13-F
MQ 1-2	Repellents for stored-grain insects **	Manhattan, Kans.	Yes	4-D-2
MQ 1-3	Fumigating stored mill rice	Houston, Tex.	Yes	4a-D-2
MQ 1-4	Controlling dermestid beetles in dry milk plants	Madison, Wis.	Yes	2-B-1,2
MQ 1-5	Drosophila flies affecting dried fruit industry	Fresno, Calif.	Yes	3-G-1,3
MQ 1-6	Fumigation studies on cheese mites **	Madison, Wis.	Yes	2-B-2
MQ 1-7	Ecology of stored-tobacco insects	Richmond, Va.	Yes	11-A-1
MQ 1-8(C)	Effects of EDB on egg laying	Athens, Ga.	Yes	4-D-5
MQ 1-9	Infrared rice dryers for insect control **	Houston, Tex.	Yes	4a-D-2
MQ 1-10	Fumigation of stored tree nuts **		No	
MQ 1-11(C)	Study of insect repellents for packaging **	Kansas City, Mo.	Yes	13-F-1
MQ 1-12	Physical energy for detecting and controlling insects **	Savannah, Ga.	Yes	13-E-1
MQ 1-13	Packaging for dry milk	Madison, Wis.	Yes	2-B-4
MQ 1-14	Insect control in farmers stock peanuts **	Tifton, Ga.	Yes	6-C-2
MQ 1-15	Laboratory evaluation of protectants for commodities **	Houston, Tex.	Yes	4a-D-1,4
MQ 1-16	Forced-distribution fumigation of grain in commerical storages **	Manhattan, Kans.	Yes	4-D-3
MQ 1-17	Storage tests of insect-resistant packages **	Savannah, Ga.	Yes	13-F-2
MQ 1-18	Effects of air movement on stored-grain insects **	Manhattan, Kans.	Yes	4-D-1
MQ 1-19	Protective treatments for rough rice **	Houston, Tex.	Yes	4a-D-2
MQ 1-20	Preliminary evaluations of compounds for insect-resistant packages **	Savannah, Ga.	Yes	13-F-1
MQ 1-21	Preliminary storage tests of insect-resistant package treatments **	Savannah, Ga.	Yes	13-F-2
MQ 1-22	Physical resistance of packages to insects **	Savannah, Ga.	Yes	13-F-2
MQ 1-23	Preliminary evaluation of insecticides **	Savannah, Ga.	Yes	13-B-1
MQ 1-24	Development of aerosal and mist spray formulations **	Savannah, Ga.	Yes	13-B-1
MQ 1-25	Spray application studies for warehouses **	Savannah, Ga.	Yes	13-E-1
MQ 1-26	Laboratory evaluation of mothproofing compounds **	Savannah, Ga.	Yes	8-B-1
MQ 1-27	Intermediate evaluation of grain protectants	Manhattan, Kans.	Yes	4-D-2
MQ 1-28	Laboratory evaluation of fumigants for stored-product insects **	Savannah, Ga.	Yes	13-B-2
MQ 1-29	Determination of chemical residues **	Savannah, Ga.	Yes	13-D-1
MQ 1-30(C)	Insect damage to stored corn in the Southeast **	Auburn, Ala.	Yes	4-D-3
MQ 1-31	Preconditioning stored-product insects to fumigants **	Manhattan, Kans.	Yes	4-D-1
BS 1-30(Rev.)	Control of insects in stored tobacco *	Richmond, Va.	Yes	11-A-3
BS 1-30	Fumigation of bulk rough rice *	Houston, Tex.	Yes	4a-D-2
BS 1-34	Protective sprays for stored wheat *	Manhattan, Kans.	Yes	4-D-3
BS 1-35	Forced-distribution fumigation of grain in elevators *		No	
BS 1-36	Forced-distribution fumigation of grain in flat storages *	Manhattan, Kans.	Yes	4-D-3
BS 1-40	Insect control in country wheat elevators *	Manhattan, Kans.	Yes	4-D-3
BS 1-41	Moth control in country grain elevators *		No	
BS 1-42	Treatment of infested grain arriving at country elevators between harvest periods *		No	
BS 1-43	Studies of dermestids in stored grain *		No	
BS 1-44(C)	Performance of different protective spray formulations for stored wheat *		No	
BS 1-53	Insecticide equipment for stored-product insects *	Savannah, Ga.	Yes	13-C-1
BS 1-55	Application of mothproofing compounds *	Savannah, Ga.	Yes	8-B-1
BS 1-56	Protection against insect damage for textiles stored in containers *	Savannah, Ga.	Yes	8-B-2
BS 1-57	Treatments of fabrics for storage protection against insect damage *	Savannah, Ga.	Yes	8-B-2
BS 1-58	Resistance of hybrid corn to insect attack *		No	
BS 1-59	Insect problems of oats in commerical storage *		No	
BS 1-60	Fumigation of farm-stored corn in the Southeast *		No	
BS 1-61	Protective sprays for stored corn *		No	
BS 1-66(Rev)	Insect infestation in dried fruit *		No	
BS 1-67	Residual sprays for cheese mites *	Madison, Wis.	Yes	2-B-2

Continued next page



Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962 cont'd

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
BS 1-69	Fumigation studies on cigarette beetle *	Richmond, Va.	Yes	11-A-3
BS 1-70	Fumigation of tobacco warehouses *	Richmond, Va.	Yes	11-A-3
BS 1-83	Aerosol treatment of stored grain *		No	
BS 1-87	Gravity penetration of liquid fumigants in grain *		No	
CCC-1-1	Insect Control in CCC-stored grain **	Manhattan, Kans.	Yes	4-D-1,3,4
10(Rev.)		Watseka, Ill.		
A10-AMS		Savannah, Ga.		
4(a)	Effect of EDB on animals	Rehovot, Israel	Yes	4-D-5
A10-AMS	Influence of environmental factors on population dynamics	Jerusalem, Israel	Yes	4-D-1
11(k)	of khapra beetle **			
A17-AMS	Effectiveness of grain protectants against khapra beetle	Karachi, Pakistan	Yes	4-D-3
1(k)				
A17-AMS	Effects of gamma radiation on stored-grain insects **	Karachi, Pakistan	No	
3(k)				
E8-AMS	Studies of pesticide residues	Helsinki, Finland	Yes	13-D-2
1(a)				
E15-AMS	Fate and effect of pesticide residues on seeds **	Padua, Italy	No	
3(a)				
E15-AMS	Persistence and fate of pesticide residues in wheat **	Rome, Italy	No	
8(a)				
E15-AMS	Insect infestation in spaghetti, macaroni, and noodles **	Rome, Italy	No	
9(a)				
E15-AMS	Study of pesticide residues with radioactive tracers **	Florence, Italy	No	
14(a)				
E21-AMS	Nutritional requirements of mites	Warsaw, Poland	Yes	13-A-1
1(a)				
E21-AMS	Biological control of grain moths **	Poznan, Poland	Yes	13-E-1
4(a)				
S9-AMS-	Underground storage of corn **	Montevideo, Uruguay	Yes	4-D-4
6(a)				
	*Discontinued during reporting period			
	**Initiated during reporting period			

Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
MQ 2	Maintaining and improving agricultural product quality in storage, transportation, and handling. Program Leadership	Beltsville, Md.		
MQ 2-1	Rind breakdown of citrus fruit *	Orlando, Fla. Harlingen, Tex.	Yes	1-D-1
MQ 2-2	Decay and quality of California globe artichokes	Fresno, Calif.	Yes	12-F-1
MQ 2-3	Decay of action of bacterial soft rot	New York, N. Y.	Yes	9-F-3
MQ 2-4	Quality maintenance in blueberries	Raleigh, N. C.	Yes	3-D-4, 3-E-5
MQ 2-5	Precut seed potatoes	Beltsville, Md.	Yes	9-F-2
MQ 2-6	Shelf life of ice-packed poultry	Beltsville, Md.	Yes	10-B-3
MQ 2-7	Control of deterioration of rough rice	College Station	Yes	4a-B,C
MQ 2-8	Storage and chipping quality of new potato varieties	East Grand Forks, Minn.	No	
MQ 2-9	Dried fruits in marketing channels	Fresno, Calif.	Yes	3-C-6
MQ 2-10	Washing, cooling and draining of poultry	Beltsville, Md.	Yes	10-B-2, 3
MQ 2-11	Russet spotting of lettuce	Fresno, Calif.	Yes	12-E-1
MQ 2-12	Storage of plums	Fresno, Calif.	Yes	3-C-4
MQ 2-13	Modified atmospheres, containers, transit services on asparagus	Fresno, Calif.	Yes	12-D-1
MQ 2-14	Transportation and marketing western melons	Fresno, Calif.	Yes	12-D-4
MQ 2-15	Cut flowers and ornamentals	Fresno, Calif.	Yes	11b-A-1
MQ 2-16	Softening of brined cherries **	Wenatchee, Wash.	Yes	3-F-5
MQ 2-17	Effect of varying temperatures on quality		No	
MQ 2-18	Transportation in mechanical refrigerator cars		No	
MQ 2-19	Low temperatures on quality of seed potatoes	Beltsville, Md. Delaware, Maine New York, Fresno, Calif.	Yes	9-D-2
MQ 2-20	Strawberry decay control			
MQ 2-21	Leading pattern and icing practices on celery and peas **	Fresno, Calif.	Yes	3-D-2 3-F-6
MQ 2-22	Decay control in eastern peaches	Beltsville, Md.	Yes	12-D-6 3-F-2
MQ 2-23	Maintaining quality of vine ripened tomatoes	Beltsville, Md.	Yes	12-B-4 12-D-7
MQ 2-24	Pre-harvest infection of citrus fruit and post-harvest decay	Pomona, Calif.	Yes	1-E-3
MQ 2-25	Maintaining quality of Hawaiian fruits	Hawaii Pomona, Calif.	Yes	1-C-4
MQ 2-26	Biphenyl resistance of Penicillium on citrus decay	Pomona, Calif.	Yes	1-E-2
MQ 2-27	Maintaining quality of California Citrus in transit		No	
MQ 2-28	Accumulation of biphenyl in citrus and effect on decay	Pomona, Calif.	Yes	1-E-1
MQ 2-29	Detection and description of freezing injury **	Beltsville, Md.	Yes	12-C-4
MQ 2-30	Quality maintenance in dry beans	Beltsville, Md.	Yes	12-D-2
MQ 2-31	Chemicals for control of sprouting	Beltsville, Md.	Yes	9-C-4
MQ 2-32	Gamma irradiation of fruits and vegetables	Chicago, Ill.	Yes	1-E-5, 3-F-2, 4
MQ 2-33	Packaging eastern peaches and nectarines	Beltsville, Md.	Yes	3-B-2
MQ 2-34	Oxidative deterioration in dry corn	Ames, Iowa	Yes	4-B-1
MQ 2-35	Venelation on quality of Maine potatoes	Presque Isle, Maine	Yes	9-C-2
MQ 2-36	Improved packaging of mature green tomatoes **	Beltsville, Md. Fla., Tex. New York, Chicago	Yes	12-B-4
MQ 2-37	Black spot of potatoes	Presque Isle, Maine	Yes	9-C-3
MQ 2-38	Quality changes in apples and onions during marketing	New York, N. Y.	Yes	12-B-6
MQ 2-39	Prestorage treatments of potato diseases	Presque Isle, Maine	Yes	9-C-3 9-F-1
MQ 2-40	Storage and shelf life of Persian limes	Miami, Fla.	Yes	1-B-4
MQ 2-41	Maintenance of quality of poultry in S. E. states	Georgia	Yes	10-B-2, 3, 4
	Continued next page			

## Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962 cont'd

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
MQ 2-42	Leading methods and protective services for Maine potatoes **		No	
MQ 2-43	Black Leaf Speck of cabbage **	New York, N. Y.	Yes	12-F-4
MQ 2-44	Long term storage of vegetable oils **	Washington, D.C.	Yes	6-B-2
MQ 2-45	Modified atmospheres for berries **	Beltsville, Md.	Yes	3-F-7
MQ 2-46	Ripening of mangoes and avocados	Miami, Fla.	Yes	1-B-3
MQ 2-47	Decay of Florida endive, escarole, cabbage, celery **	Orlando, Fla.	Yes	12-F-5, 6, 8
MQ 2-48	Controlled atmosphere storage of citrus	Harlingen, Tex.	Yes	1-B-1
MQ 2-49	Sulfur dioxide treatment of grapes	Pomona, Calif.		
		Fresno, Calif.	Yes	3-C-5 3-D-3
MQ 2-50	Market quality southeastern potatoes **		No	3-F-3
MQ 2-51	Storage of Florida citrus **	Orlando, Fla.	Yes	1-B-2 1-C-1, 2
MQ 2-52	Gray mold of peppers **	Chicago, Ill.	Yes	12-F-10
MQ 2-53	Precooling and transportation Florida citrus fruits and vegetables **	Orlando, Fla.	Yes	1-C-3
MQ 2-54	Tomato fruit tumor (waxy blister)	Harlingen, Tex.	Yes	12-E-5
MQ 2-55	Transit temperatures - California potatoes **	Fresno, Calif.	Yes	9-D-1
MQ 2-56	Physiological breakdown in stored onions **	Fresno, Calif.	Yes	12-C-1
MQ 2-57	Controlled atmospheres for Western apples **	Wenatchee, Wash.	Yes	3-C-1
		Fresno, Calif.		
MQ 2-58	Market quality western lettuce **	Fresno, Calif.	Yes	12-D-5
MQ 2-59	Market Diseases of cucurbits **	Chicago, Ill.	Yes	12-F-14
MQ 2-60	Host-parasite physiology of market diseases **	Beltsville, Md.	Yes	12-F-12, 13
MQ 2-61	Antioxidants, metabolic inhibitors on vegetables **	New York, N. Y.	Yes	12-B-3, 9
		Beltsville, Md.		
MQ 2-62	Deterioration of grass seed **	Beltsville, Md.	Yes	4b-B-1
MQ 2-63	Plastic film liners for eastern apples **	Beltsville, Md.	Yes	3-B-1
MQ 2-64	New market diseases	Chicago, Ill.	Yes	3-F-2, 6
		New York, N. Y.		12-F-2, 7, 9, 11
MQ 2-65	Post-harvest diseases Florida citrus **	Orlando, Fla.	Yes	1-E-4
MQ 2-66	Control of pear scald **	Wenatchee, Wash.	Yes	3-E-3
MQ 2-68	Anthracoise of avocado and mango fruits **	Miami, Fla.	Yes	1-E-6
MQ 2-69	Influence of storage temperature on processing quality of potatoes **	East Grand Forks, Minn.	Yes	9-C-1
BS 2-39	Ice-packed poultry in paper containers *	Beltsville, Md.	Yes	10-B-1
BS 2-44	Weight loss of fruit and vegetables after harvest *		No	
BS 2-45	Provitamin A content as related to wilting *		No	
BS 2-50	Fungicidal methods for post-harvest diseases of Florida citrus *	Orlando, Fla.	Yes	1-E-4
BS 2-55	Packaging western peaches *		No	
BS 2-59	Film liners for grapes *		No	
BS 2-65	Film liners for pears *	Fresno, Calif.	Yes	3-C-2, 3
BS 2-66	Thermostatic control of car temperatures *		No	
BS 2-68	Yellow Newtown apples in sealed film liners *	Fresno, Calif.	Yes	3-B-1
BS 2-70	Precooling and transit refrigeration of lettuce *	Fresno, Calif.	Yes	12-B-5 12-E-3
BS 2-71	Vacuum cooling of fruits and vegetables *	New York, N. Y.	Yes	12-B-2
		Fresno, Calif.		12-D-3
BS 2-74	Antibiotics for fresh vegetables *	New York, N. Y.	Yes	12-F-3
BS 2-78	Commercial storage of potatoes for chips *		No	
BS 2-84	Control of apple scald *	Beltsville, Md.	Yes	3-E-1
		Wenatchee, Wash.		
BS 2-85	Ripening of mature green tomatoes *	Beltsville, Md.	Yes	12-E-2
BS 2-86	Discoloration of potatoes after cooking *	Beltsville, Md.	Yes	9-E-1
BS 2-90	Phenolase and cytochrome oxidase during aging *		No	
BS 2-97	Plastic bags and liners for vegetable plants *	Beltsville, Md.	Yes	12-B-7
BS 2-100	Symptoms and effects of chilling injury *		No	
BS 2-108	Bulls eye rot of apples *	Wenatchee, Wash.	Yes	3-F-1
	Continued next page			



Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962 cont'd

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
BS 2-109	Control of decay in apples and pears *	Wenatchee, Wash.	Yes	3-F-1
BS 2-110	Fiberboard boxes for apples *		No	
BS 2-112	Film liners for plums *		No	
BS 2-113	Brown core of Anjou pears *	Corvallis, Ore.	Yes	3-E-4
(C)				
BS 2-114	Controlled atmosphere storage of northwestern apples *	Wenatchee, Wash	Yes	3-C-1
BS 2-115	Transportation of Barlett pears *	Fresno, Calif.	Yes	3-D-1
BS 2-117	Freezing injury to apples in transit *		No	
BS 2-118	Control of sweet cherry decays *		No	
BS 2-119	Control of soft scald of apples *		No	
BS 2-122	Handling and storing Maine potatoes *		No	
BS 2-124	Diseases of Mangoes and avocados *	Miami, Fla.	Yes	1-E-6
		Orlando, Fla.		
BS 2-130	Decay of sweet potatoes during marketing *	Raleigh, N. C.	Yes	12-F-12
		Beltsville, Md.	Yes	12-C-2
BS 2-132	Control of decay in peaches for processing *	Wenatchee, Wash.	Yes	3-F-2
BS 2-133	Market diseases of watermelons *	Chicago, Ill.	Yes	12-F-14
BS 2-137	Storage of strawberry plants *	Beltsville, Md.	Yes	3-C-7
BS 2-140	Shipping western fruits and vegetables by truck *		No	
BS 2-141	Respiration of Texas fruits and vegetables *	Harlingen, Tex.	Yes	12-E-4
BS 2-142	Winter shipment of Florida vegetables to Canada *		No	
BS 2-144	Packaging of seeds *	Ames, Iowa	Yes	4b-B-1
(C)				
BS 2-150	Handling, transportation and packaging of California potatoes *	Fresno, Calif.	Yes	9-D-1
BS 2-160	Microbiological and physiological deterioration of beans *	E. Lansing, Mich.	Yes	12-B-1
BS 2-162	Transit studies of Florida avocados, limes and mangoes *		No	
BS 2-165	Truck-rail (piggy back) services*		No	
BS 2-171	Export tests on California citrus *		No	
BS 2-190	Development of unit for spectrocord *	Beltsville, Md.	Yes	3-E-6
BS 00-1	Storage of vegetables for Navy *	Beltsville, Md.	Yes	12-C-3
E8-AMS-1	Residues of post-harvest chemicals	Helsinki,	Yes	3-F-8
(a)		Finland		
E15-AMS-4(a)	X-ray research applied to fruit pathology **	Italy	Yes	3-F-9
E29-AMS-1	Apple respiration in modified atmospheres	Kent, England	Yes	3-E-2
S5-AMS-3	Chemical and physiological variables of avocados and papayas		No	
	*Discontinued during reporting period			
	**Initiated during reporting period			

Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
MQ 3	Basic research on quality evaluation and development of objective measurement of quality factors in agricultural products. Program Leadership	Beltsville, Md.		
MQ 3-1	Development of a small scale spinning test	Clemson, S. C.	Yes	7-A-5
MQ 3-2	Field evaluation of equipment for oil and moisture measurements of soybeans *	Washington, D.C.	Yes	6-A-3
MQ 3-3	Quality indicators for stored wheat	Washington, D.C.		
MQ 3-4	Rapid determination of length and length distribution of cotton fibers	Clarksdale, Miss.		
MQ 3-5	Rapid measurement of oil and moisture content of cotton seed	Decatur, Ill.		
MQ 3-6	Elastic energy as a means of indicating spinning potential of cotton	Mankato, Minn.	Yes	4-A-2
MQ 3-7	Integration of measurements for oil content and quality of cottonseed oil	Kansas City, Mo.	Yes	7-A-2
MQ 3-8	Seed blending methods for commercial seed lots (C)	Beltsville, Md.	Yes	7-B-1
MQ 3-9	Study of the factors influencing quality in pork (C)	College Sta. Tex.	Yes	7-A-6
MQ 3-10	The influence of bovine age upon the characteristics of meat and carcass grade (C)	Clemson, S. C.	Yes	7-B-2
MQ 3-11	Simplified screening tests for chlorinated hydrocarbon pesticide residues in dairy products	Washington, D.C.	Yes	4b-A-4
MQ 3-12	Identification of rice varieties	Beltsville, Md.	Yes	5-A-3
MQ 3-13	Relation of spinning performance of cotton to color grade (C)	State College, Miss.	Yes	5-A-4
MQ 3-14	Quick dye methods for determination of protein content of milk (C)	Beltsville, Md.	Yes	2-A-1
MQ 3-15	Evalvaling quality of tomatoes for processing	Beltsville, Md.	Yes	4a-A-1
MQ 3-16	Objective measurements for determining the degree of milling of rice **	Lubbock, Tex.	Yes	7-A-4
MQ 3-17	Relation of cotton fiber measures and properties to yarn strength and appearance **	Davis, Calif.	Yes	2-A-2
MQ 3-18	Quick test for detection of damage by heat in artificially dried corn	Beltsville, Md.	Yes	12-A-2
MQ 3-19	Classification of seedlings of southern crop seeds	College Station, Tex.	Yes	4a-A-2
MQ 3-20	Seasonal changes and metabolic activity of oranges ** (C)	Washington, D.C.	Yes	7-A-3
MQ 3-21	Mechanization of seed purity analysis ** (C)	Beltsville, Md.	Yes	4b-A-2
MQ 3-22	Disease syndromes of market poultry ** (C)	Raleigh, N. C.	Yes	4-A-1
MQ 3-23	Determination of moisture in grain, seeds, and oilseeds **	Beltsville, Md.	Yes	4b-A-1
MQ 3-24	Equipment for sampling and grading small grains and soybeans **	Orlando, Fla.	Yes	1-A-2
MQ 3-25	Oil quality changes in long term storage **	Beltsville, Md.	Yes	4b-A-5
MQ 3-26	Defect evaluation of peanuts (C)	Corvallis, Ore.	Yes	10-A-4
MQ 3-27	Quality measurement of red tart cherries **	Davis, Calif.	Yes	4-A-6
MQ 3-28	Quality measurement of apples **	Beltsville, Md.	Yes	4-A-5
MQ 3-29	Methods and equipment for grading farmers' stock peanuts **	Washington, D.C.	Yes	6-B-2
MQ 3-30	Lighting system for grain inspection **	Beltsville, Md.	Yes	6-A-2
MQ 3-31	Assessing the sanitary quality of commerical egg solids **	College Sta. Tex.	Yes	3-A-3
		Penn. & Mich.	Yes	3-A-1,2
		Beltsville, Md.	Yes	
		Wenatchee, Wash.	Yes	6-A-1
		Raleigh, N. C.	Yes	4-A-3
		Beltsville, Md.	Yes	10-A-1
	Continued next page			

Line Project Check List -- Reporting Period October 1, 1960 to September 30, 1962 cont'd

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
MQ 3-32	Seed metabolism **	Beltsville, Md.	Yes	4b-A-3
MQ 3-33	Effects of various production, harvesting, and ginning practices on spinning performance and cotton quality **	Clemson, S. C.	Yes	7-A-1
MQ 3-34	Evaluating market quality of livestock and meat **	Beltsville, Md.	Yes	5-A-2
MQ 3-36	Measurement of flour yielding capacity of wheat **	Beltsville, Md.	Yes	4-A-7
MQ 3-37	Measuring character factors in canned southern peas	Beltsville, Md.	Yes	12-A-3
MQ 3-38	Maturity determinations in Italian prunes **	College Park, Md.		
MQ 3-40	Methods of determining susceptibility of potatoes to bruising	Wenatchee, Wash.	Yes	3-A-4
		E. Grand Forks, Minn.	Yes	9-A-1
BS 3-5	Objective methods for estimating the composition of live animals *	Beltsville, Md.	Yes	5-A-1
BS 3-29	Evaluation of relationships of cotton fiber properties to performance *	Clemson, S. C.	Yes	7-A-3
BS 3-37	Determination of smut in wheat *		No	
BS 3-44	Maturity measurements in avocados *	Miami, Fla.	Yes	1-A-3
BS 3-49	Evaluation of new sweetpotato varieties *	Beltsville, Md.	Yes	12-A-4
BS 3-54	Quality measurements of peaches for processing *	Beltsville, Md.	Yes	3-A-5
BS 3-55	Fat acidity test as an index of soundness in grain *	Beltsville, Md.	Yes	4-A-4
BS 3-59	Physical techniques for seed quality *	Beltsville, Md.	Yes	4b-A-2
BS 3-60	Evaluation procedures for wool *	Beltsville, Md.	Yes	8-A-1
BS 3-61	Quality tests for nonfat dry milk *	Beltsville, Md.	Yes	2-A-3
BS 3-65	Disease agents in dressed poultry *	Davis, Calif.	Yes	10-A-3
BS 3-66	Automatic sorting of dates for moisture *	Beltsville, Md.	Yes	1-A-4
		Los Angeles, Calif.		
BS 3-67	Seasonal changes in Murcott Honey oranges *	Orlando, Fla.	Yes	1-A-1
BS 3-68	Sampling and testing sugarcane *			
(C)				
BS 3-74	Criteria for identifying meat-type hogs and feeder pigs *	Beltsville, Md.	Yes	5-A-5
		Ill., Ind., Pa., Ohio, Mich.		
A10-AMS-7	Development of rapid tests for protein nutritive value of cereal grains and feeds **	Haifa, Israel	Yes	4-A-4b-B-2
E8-AMS-2(a)	Contamination of milk by nonpathogenic bacteria **	Finland	Yes	2-A-3
E9-AMS-4(a)	Relationship between fiber maturity and breakage **		No	
E9-AMS-5(a)	Instrument for homogenizing cotton fibers **		No	
E19-AMS-8(a)	Relation of fiber length distribution to yarn and spinning quality **		No	
E21-AMS-6(k)	Storage properties of flaxseed		Yes	6-B-1
E21-AMS-7(k)	Effect of microflora on properties of wheat flour		Yes	4-B-2
E25-AMS-1(a)	Development of objective methods for measuring market quality of raw and processed rice.	Valencia, Spain	Yes	4a-A-3
E25-AMS-5(a)	Lysozyme on quality of shell eggs in storage **	Spain	Yes	10-A-2

\*Discontinued during reporting period

\*\*Initiated during reporting period



